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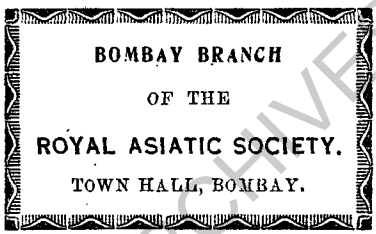

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OF

INDIAN GEOLOGY AND PHYSICAL GEOGRAPHY

WITH

AN ANNOTATED INDEX

OF

MINERALS OF ECONOMIC VALUE

II

COMPILED BY T. H. D. LA TOUCHE, M.A., F.G.S., *Fellow of the Asiatic Society of Bengal.*

38532

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Published by order of the Government of India.

CALCUTTA:
SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY OF INDIA,
27, CHOWRINGHEE ROAD.
LONDON: MESSRS. KEGAN PAUL, TRENCH, TRÜBNER & CO.

1918

NATIONAL ARCHIVES OF INDIA

PART II.—AN ANNOTATED INDEX

OF

MINERALS OF ECONOMIC VALUE

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INTRODUCTORY NOTE.

IN the compilation of these Notes my object has been to furnish a guide to the literature on the subject of Indian minerals of economic value, at the same time indicating as concisely as possible the nature of the information given by each observer, whether it be a merely casual statement, or a more or less elaborate and authoritative description of the occurrence. The Notes are intended to be used in conjunction with the Bibliography which forms the first part of this work. The figures inserted in brackets after the observer's name correspond to the serial number allotted to each author, and are followed, where necessary, by the number of the page on which the reference will be found. In the case of re-prints, or the publication of a paper in more than one periodical, the page number given is that of the first in order of publication, as shown in the Bibliography.

In one respect, it must be admitted, these Notes fail to give a complete review of our knowledge in respect of the mineral wealth of India, since they deal only with matter that has actually been published, and consequently take no account of the large number of observations that must have been accumulated by the numerous prospectors who have been busily employed in the investigation of the mineral resources of the country within recent years. Much of the information thus collected is stored up in the progress reports and correspondence files of the Geological Survey Department in Calcutta, where it was not accessible to myself; but where it may be studied, when not of a confidential nature, by those who are interested in the subject either in its scientific or commercial aspects.

The classification of the minerals in accordance with their chemical composition, adopted in the Manual of the Economic Geology of India compiled by Dr. Valentine Ball in 1881, is replaced by a less scientific, but perhaps more convenient alphabetical arrangement, which has the advantage of dispensing with the need of a separate index. Certain minerals, either economically or chemically related to each other, such as building materials, gem-stones, sulphates, etc., are grouped under a single heading, in accordance with the practice followed in the Quinquennial Reviews of Mineral Production issued by the Geological Survey. Heavy type is then used, where necessary, in order to render the names of the minerals thus grouped together more conspicuous in the text. The geographical distribution of the minerals is dealt with in a similar manner; the Provinces, including the larger Independent States, the Districts and smaller States, and finally localities being arranged in alphabetical order. Where a smaller State is included within the limits of a District, the name is inserted in brackets.

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The co-ordinates of latitude and longitude are taken, wherever possible, from the 'Atlas of India,' on the scale of 4 miles=1 inch; and in a few cases from the Standard one-inch maps. The longitudes taken from the 'Atlas' require a correction of —3′ 36″, and those from the Standard sheets of —2′ 27″, in order to reduce them to the latest value of the meridian of the Madras Observatory; but for obvious reasons it has been thought advisable to give the *uncorrected* values. Since all the places mentioned lie to the north of the equator and east of Greenwich, the indicators N. lat. and E. long. are omitted.

The spelling of the names of provinces and districts is that given in the recently published edition of the Imperial Gazetteer of India; while that of the place names generally follows the system adopted in later editions of the 'Atlas of India.'

Certain monographs on particular minerals, compiled at various times by Officers of the Geological Survey, are referred to by distinguishing letters inserted in brackets, with the number of the page on which the occurrence is described.

These are :—

Title.	Authors.	Serial No. in Bibliography.	Distinguishing letter.
1. Manual of the Economic Geology of India.	Dr. V. Ball .	71—45	B
2. Coal Fields of India . . .	Dr. V. Ball and R. R. Simpson.	72	S
3. Corundum	Sir T. H. Holland	859—25	H
4. Manganese-Ore Deposits of India.	L. L. Fermor .	577—32	I
5. Mica Deposits of India .	Sir T. H. Holland	859—37	H
6. Thermal Springs of India (Mineral Waters.)	Dr. T. Oldham and R. D. Oldham.	1327—2	O
7. Oil-fields of Burma	E. H. Pascoe	1369—11	P
8. Petroleum Occurrences of Assam and Bengal.	E. H. Pascoe	1369—13	P

I feel greatly indebted to Dr. L. L. Fermor, the recognised authority on the occurrence of manganese ore in India, for his kindness in revising the notes on that mineral.

T. H. D. LaTOUCHE.

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The following works deal generally with the distribution of economic minerals in India and in certain of the Provinces :—

INDIA.

1857. Balfour (**69**—8). Cyclopædia of India and of eastern and southern Asia.

1881. Ball (**71**—45). Manual of the economic geology of India.

1882. Ball (**71**—54). The mineral resources of India and their development.

1889-96. Watt (**1903**—1). Dictionary of the economic products of India.

1906. Simmersbach (**1637**). Die bergbauliche Entwicklung und die Metalleinfuhr von Britisch-Ostindien.

1907. Holland (**859**—65). The Indian Empire :—Mines and Minerals.

1908. Holland (**859**—69). Sketch of the mineral resources of India.

1908. Watt (**1903**—5). The commercial products of India.

1908. Freise (**622**—2). Berg-und hütten-mannische Untersuchungen in Asien und Afrika während des Altertums.

1911. de Launay (**459**—2). La géologie et les richesses minérales de l'Asie.

BURMA.

1850. Mason (**1185**—1). The natural productions of Burmah.

1879. Doyle (**501**—5). A contribution to Burman Mineralogy.

1882. Mason and Theobald (**1186**). Burma, its people and productions.

MADRAS.

1850. Hunter (**894**—5). List of articles from the mineral kingdom, the produce of the Madras Presidency.

1851. Hunter (**894**—6). Report upon the mineral products of the Madras Presidency, sent to the great national exhibition of 1851.

1851. Hunter (**894**—9). The resources of the Madras Presidency.

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PUNJAB.

1868. Baden-Powell (**60**—1). Handbook of the economic products of the Punjab.

RAJPUTANA.

1879. Blanford and Hume (**151**). Notes on the useful minerals of Rajputana.

The trend of recent developments in the exploitation of the mineral resources of India is indicated by the table given below, the figures in which are taken from the Reviews of Mineral Production (**859**—50; **861**; **862**) issued quinquennially by the Geological Survey Department; and for the years 1914 and 1915 from the annual reports of the Director (**793**—33; *Records, G. S. I.*, Vol. XLVII, Pt. 3). Columns 1 to 3 give the average values for each quinquennial period.

The minerals included are those for which approximately trustworthy returns are furnished.

Minerals.	1898 to 1903.	1904 to 1908.	1909 to 1913.	1914.	1915.
	£	£	£	£	£
Alum (*l*) .	(*i*)	2,047	2,812	4,649	4,393
Amber . .	362	648	182	274	199
Chromite (*a*) .	(*i*)	9,110	4,282	2,611	3,531
Coal (*a*) .	1,225,677	2,139,249	2,969,305	3,907,380	3,781,064
Copper Ore .	(*i*)	(*i*)	5,732	7,204	14,38[illegible]
Corundum (*e*)	(*m*) 312	(*m*) 170	1,385	447	277
Diamonds .	(*i*)	2,799	872	791	603
Gold . .	1,904,719	2,266,307	2,241,844	2,338,355	2,369,486
Graphite .	(*e*) 11,981	(*a*) 12,879	(*k*) 16,363	(*i*)	158
Gypsum .	(*i*)	161	774	979	979

(*a*) *Spot prices.* (*e*) *Estimated value.* (*i*) *No returns available.* (*k*) *Production ceased in 1912.* (*l*) *In Mianwali, Punjab.* (*m*) *In Mysore.*

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Minerals.	1898 to 1903.	1904 to 1908.	1909 to 1913.	1914.	1915.
	£	£	£	£	£
Iron Ore	(*f*) 13,584	(*f*) 13,769	(*g*) 29,519	40,665	31,886
Jadestone (*b*)	44,770	61,353	55,373	40,092	52,070
Lead and Lead Ore.	(*i*)	(*i*)	128,782	202,330	316,182
Magnesite (*e*)	519	689	2,403	557	3,973
Manganese Ore (*c*)	79,443	631,760	822,876	877,264	929,546
Mica (*b*)	80,120	170,126	230,747	237,310	183,947
Monazite	(*i*)	(*i*)	(*h*) 35,825	41,411	33,238
Petroleum (*a*)	185,810	592,887	928,072	958,565	1,256,803
Ruby, Sapphire and Spinel.	89,345	84,406	63,272	43,133	36,298
Salt (*d*)	347,897	451,339	507,294	483,289	660,254
Saltpetre (*b*)	262,603	268,012	240,289	272,462	373,891
Silver	(*i*)	(*i*)	(*n*) 9,341	(*n*) 26,896	31,150
Steatite (*e*)	1,900	608	2,524	4,146	2,578
Tin Ore and Tin.	6,875	(*a*) 10,992	30,100	38,203	54,980
Tungsten Ore	(*i*)	(*i*)	76,481	178,543	296,772
Zinc Ore	(*i*)	(*i*)	(*i*)	(*n*) 10,762	174

(*a*) *Spot prices.* (*b*) *Export values.* (*c*) *Export values of quantities actually exported.* (*d*) *Prices without duty.* (*e*) *Estimated value.* (*f*) *Value estimated for provinces other than Bengal.* (*g*) *Value estimated for provinces other than Bengal, Bihar and Orissa.* (*h*) *Average for 3 years.* (*i*) *No returns available.* (*n*) *At Bawdwin, Upper Burma.*

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AGATE *see under* **GEM-STONES.**

ALUM.

AFGHANISTAN.

Griesbach (**708**—21, 91) mentions the occurrence of alum shales at several distinct horizons in the Carboniferous rocks of the Kam Shilman valley, to the N. E. of LANDI KOTAL (34° 6′ : 71° 9′).

ASSAM.

Lakhimpur.—MAKUM (27° 18′ : 95° 41′). Mallet (**1159**—9, 361) suggests that alum and sulphate of iron might be profitably manufactured from the pyritous shales associated with the coal seams of Upper Assam (**B.** 435).

BIHAR AND ORISSA.

Gaya.—RAJGHIR HILLS. An impure native sulphate of alumina (*salajit*) is described by Martin (**1181,** Vol. I, 254) as exuding from the face of a cliff at HANGRIYO (? HANREEA, 24° 57′ : 85° 28′) in the 'Rajagriha' hills. The beds from which the mineral exudes are situated in an almost inaccessible position, about 30 feet above the mouth of a cave. The substance is sold in the bazaars as a medicine (*see under* NEPAL).

Shahabad.—ROHTASGARH (24° 38′ : 83° 58′). According to Sherwill (**1625**—5, 284), thick beds of alum shale are exposed at the base of the Kaimur sandstones in the glens in the neighbourhood of Rohtasgarh, and in the valleys of the DURGUTI and SUGIA-KOH rivers. The alum is associated with masses of pyrites and with sulphate of iron. Small quantities of alum were being manufactured at PHULWARIA, to the N. of Rohtasgarh and 4 miles W. of the Son R., for sale as a medicine (**1625**—4, 58; —6, 17). Martin (**1181,** Vol. I, 529) describes the same occurrences, and says that the band of alum shale is about 10 feet thick (**B.** 431).

BOMBAY.

Belgaum.—GOKAK (16° 10′ : 74° 53′). Newbold (**1294**—20, 22; —41, 279) notes the occurrence of shales containing an appreciable quantity of alum at the foot of the Gokak Falls on the Ghatprabha R.

Cutch.—MHURR (23° 33′ : 69° 0′ 30″). Considerable quantities of alum were formerly manufactured at Mhurr from pyritous shales associated with a soft aluminous pseudo-breccia of the sub-nummulitic group in Cutch. Narrow, tortuous passages are driven into the deposit, to a depth of about 100 feet, and the material excavated is exposed to

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the air in heaps for a period of four to five months, during which slow combustion takes place owing to the decomposition of the pyrites. It is then spread out and sprinkled with water for twelve days, when the resulting efflorescence, called *phitkari ka bij* (seed of alum), is collected and boiled in large iron pans with the addition of saltpetre or other potash salt, obtained by lixiviating the earth from village refuse heaps in the neighbourhood, in the proportion of 16 of the 'alum seed' to 6 of the potash salt. The liquor is then allowed to crystallise in small earthen vessels. The crystals are re-boiled one or more times to concentrate and purify the solution, which is then placed in large earthen pots sunk in the ground, where the alum finally crystallises out in large masses (Anon., **35**—1 ; Grant, **691**—3, 295 ; Jacob, **924**—5, 59 ; Wynne, **1975**—11, 87).

Macmurdo (**1145**—1, 210) gives a similar account of the manufacture of alum from the water of a tepid spring called the CHACHERA KUND, a short distance to the north of Mhurr.

In the year 1862 Jacob estimated the production of alum at Mhurr as from 28,000 to 35,000 cwt. annually ; but in 1872, according to Wynne, it had fallen to about 6,000 cwt. Subsequently the demand ceased altogether, and the industry died out (**B.** 432).

Goa.—MORMUGAO (15° 24′ : 73° 51′). Fermór (**577**—27) has noted the occurrence of an efflorescence of potash alum on the face of a cliff composed of altered argillaceous rocks, probably of Dharwarian age, close to the railway station at Mormugao. It is derived from particles of pyrites disseminated through the rock. The commercial value of the deposit depends upon the amount of pyrites that still remains undecomposed.

Sind.—Alum is manufactured from pyritous shales in the Gaj beds on the MAKI NAI (27° 3′ : 67° 23′) and at several other places among the hills of western Sind ; also from shales in the Ranikot group at RANIKOT (25° 54′ : 67° 56′) ; and in the Nari group at BILL (25° 37′ : 67° 33′) in the Kohistan Taluk (Blanford, **148**—63, 195). Another locality, SHAH HASSAN near TRINI (26° 23′ : 67° 43′ 30″), is mentioned by Vicary (**1845**—5, 343). The process of manufacture was not observed, but is said to consist in burning the shale and lixiviating it when burnt, with the addition of a potash salt (**B.** 433).

BURMA.

Salween.— A discovery of alum shales in the neighbourhood of the YUNZALIN R. (17° 30′ : 97° 40′) was reported by Brandis in 1862 (**B.** 435).

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Tavoy.—Mason (**1185**—1, 33) records the occurrence of alum in soft reddish clay slates in the valley of the Tenasserim R., about 40 miles below MATAH (? MYITTHÁ, 14° 10′ : 98° 32′).

MADRAS.

Travancore.—Clays containing thin laminæ of pyrites, giving rise to an efflorescence of bright yellow alum, are exposed, according to King (**987**—26, 98), in cliffs of the Warkalli beds between WARKALLI (8° 44′ : 76° 46′) and ANJENGO (8° 40′ : 76° 49′). The alum clays are about 25 feet in thickness.

NEPAL.

Alum is found exuding from soft rocks at many localities among the hills of Nepal, and is exported under the name of *salajit* or *silajit* to the bazaars of India, where it is held in great repute as a medicine. Campbell (**267**—2) says that the quantity exported is not more than 11 or 14 cwt. annually. A sample purchased by Stevenson was found to contain 95 per cent. of sulphate of alumina with 3 per cent. of iron (**1698**—2); but the proportion of sulphate of alumina in average qualities is said to be about 66 per cent.

A substance known as black *salajit*, also used for medicinal purposes, is of an entirely different composition. It is a dark brown substance of a bituminous-like consistence, and according to Hooper (**868**—1) is an extractive matter containing an organic acid combined with alkalis, soluble in water. It is probably of vegetable or animal origin (**B.** 435).

PUNJAB.

Jhelum.—The highly pyritous shales associated with Tertiary coal seams at the DANDOT COLLIERY (32° 39′ : 73° 0′) might be used, as Daru (**421**—2, 281) suggests, as a source of alum. Wynne (**1975**—18, 301) states that the manufacture of alum was formerly carried on at VIRGAL (32° 27′ : 72° 7′) and AMB (32° 30′ : 71° 59′), in the Salt Range, from black shales on the same horizon as at Dandot, that is to say, at the base of the nummulitic limestone of the plateau (**B.** 434).

Mianwali.—KALABAGH (32° 58′ : 71° 37′) and KOTKI (32° 59′ : 71° 28′). Practically the whole of the alum now produced in India on a commercial scale is manufactured at Kalabagh, situated on the Indus at the eastern end of the trans-Indus Salt Range, and in the neighbourhood. The earliest mention of the industry is by Mohan Lal in 1838 (**1234**—1, 26), who gives a brief description of the process of manufacture. Subsequently full accounts were published by Jameson

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(**931**—3, 212), Fleming (**591**—1, 522 ; —3, 685 ; —5, 335), and Wynne (**1975**—18, 301 ; —28, 303, quoting Fleming) ; but the most complete is that given by Daru in 1910 (**421**—2), from which the following abstract is derived.

In the Salt Range near Kalabagh, alum shales are found at two distinct horizons in the Eocene (nummulitic) series, and again at the base of the underlying Jurassic series. Only one of these beds, situated at or near the base of the Eocene, is sufficiently rich in sulphur content to be used for alum making. The thickness varies from 7 or 10 feet at Kalabagh to 25 or 40 feet at the head of the Chichali pass near Kotki, a distance of 9 miles. About a mile beyond the latter locality it appears to die out. The pyrites is disseminated through the shales in microscopic particles, and the proportion of sulphur varies greatly, from 2 to nearly 13 per cent. Workable shale, known as *rol*, contains an average of 9·5 of sulphur, and is distributed in patches through the bed. Mining is conducted on no systematic plan, but the mineral is extracted by means of narrow, tortuous passages, rendered unbearably hot by reason of the decomposition of the pyrites, and without any provision either for ventilation or drainage.

The shale brought from the mines is built up with layers of brushwood, and of clay that has been once burnt and exposed to the weather for at least a year, into heaps about 18 feet in height, and roasted, fresh layers being added at one side of the heap, while the other is cut out for leaching. The burnt clay is added in order to absorb as much as possible of the sulphurous fumes from the fresh shale, but much of the sulphur is lost by volatilisation.

The process of lixiviation is somewhat complicated. The roasted shale is steeped in water for two days in tanks (*gádán*), lined with a mixture of re-burnt wood ashes, lime and cowdung, and the liquor is run into a settling tank (*chorh*), where it remains for 24 hours. In the meantime another portion of burnt shale has been steeped for 25 hours with some of the mother liquor from the crystallisation tanks in a smaller tank (*toi*). The solution from the *chorh* and *toi* are then boiled together for an hour in large iron pans, and run into a final settling tank (*nitár*), which is filled with the remainder of the mother liquor. After resting for 8 hours, half the contents of the *nitár* are boiled for 3 hours, when a certain proportion of *shora*, a mixture of chlorides, nitrates and sulphates of soda and of potash, with traces of carbonates, obtained by leaching out the efflorescent soil found at various places in the district, is added. Boiling is continued for another 7 hours, when the contents of the pan are transferred to a crystallising tank, and the pans are filled with the liquor remaining in the *nitár*. The crude crystals are removed after 5 or 6 days, and are purified by fusing them for 2 hours

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in their own water of crystallisation. The liquor is finally crystallised in large earthenware jars half sunk in the ground.

It is pointed out by Daru that the use of lime in the lixiviating tanks results in a very considerable loss of alum, and that this would be avoided by lining them with gypsum, which is found in abundance at Kalabagh itself.

The output at the time of Fleming's visit (1852) is said to have been about 8,600 cwt. at Kalabagh, and 7,000 cwt. at Kotki, where the works had recently been started; but in Wynne's time only one kiln was at work at Kotki, and no alum was being made at Kalabagh (**B.** 434).

The average annual production for the five years 1909 to 1913 amounted to 6,035 cwt. In 1914 it was 8,731 cwt., and in 1915, 7,026 cwt.

RAJPUTANA.

Jaipur.—KHETRI (28° 0′ : 75° 51′) and SINGHANA (28° 6′ : 75° 54′). Considerable quantities of alum were formerly obtained as a bye-product in the manufacture of copper and iron sulphates from the decomposed slate and refuse of the copper mines at these places. A full description of the process is given by Brooke (**203**—2, 525). The sulphates are leached out in rows of earthen jars and concentrated by boiling, when the copper sulphate crystallises out. The mother liquor is again boiled, and saltpetre is added, alum then crystallising at the bottom of the vessel (**B.** 431).

According to Hacket (**730**—4, 247), alum was made by a similar process at the copper mines of DARIBO (27° 10′ : 76° 27′) in the neighbouring State of Alwar.

No statistics of the production at either of these places are available.

UNITED PROVINCES.

Almora.—Herbert (**827**—6, 230) records the occurrence of alum as an efflorescence on pyritous slates in the bed of the KOSILA R. (29° 33′ : 79° 40′) near Almora; and in the same manner on pyritous shales near the village of JAKH (29° 26′ : 79° 31′), on the road from Naini Tal to Khairna. Here, according to Atkinson (**48,** 36), it is found in abundance. It is collected and sold for medicinal purposes as *salajit* (*see under* NEPAL) (**B.** 431).

ALUMINIUM *see* **BAUXITE.**

ALUNOGEN.

BALUCHISTAN.

Kachhi.—SANNI (29° 9′ : 67° 37′). An occurrence of alunogen (sulphate of alumina) in an almost pure state, forming veins in

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sulphur, is recorded by Tipper (**1787**—5), at the sulphur mines of Sanni, on the Bhitari R. It has been used as a mordant. Both the sulphur and the alunogen have been deposited by sulphurous springs.

AMBER.

BURMA.

Chindwin (Upper).—MAINGHKWAN (26° 18′ 30″ : 96° 32′). The only locality within the limits of the Indian Empire where amber is produced on a commercial scale is situated in the Hukawng valley in Upper Burma, inhabited by Singpho clans. The earliest accounts of the diggings were given by Hannay (**1385**, 274), who visited them in 1836, and Griffith (**709**—4, 77), who travelled over the same ground in the following year. The mines are situated along the crest of a range of low hills extending in a southerly direction from near Mainghkwan to the village of Lalaung, a distance of 7 or 8 miles. The amber is found at depths varying from 20 to 40 feet below the surface, in a bed of blue clay, and is generally associated with bands of lignite. The pits are rectangular in section, of a size just sufficient for a single man to work in them; and as there are no surface indications to guide the miners, are sunk in a haphazard manner, thickly clustered together wherever a lucky find has been made. When this occurs the adjoining pits are connected together below ground, and all the amber is taken out (**B.** 57).

These accounts agree substantially with that given by Noetling fifty-six years later, in 1892 (**1311**—8). He was unable, owing to the absence of fossils, to determine precisely the age of the blue clay in which the amber is found, but was of opinion that it probably belongs to the lower Miocene. Further details are contained in another paper, published by Noetling in the following year (**1311**—11).

The Burmese amber is slightly harder and of higher specific gravity than Baltic amber. It varies in colour from a bright pale yellow to reddish and dull brown. The clouded variety does not occur. It is remarkable for a strong bluish-green fluorescence, resembling in this respect the Sicilian variety *simetite*. Many of the pieces are traversed by cracks lined with calcspar, as was pointed out by Brewster in 1834 (**194**—3). Specimens obtained by Noetling have been examined by Helm (**810**—1; —2; —3), who found that the products of distillation included formic acid and pyrogallol in place of succinic acid. He therefore gave the name of *burmite* to this variety of amber. On the other hand, Meyer (**1214**—2, 51) states, on the authority of Dr. Oster, that a specimen of Burmese amber, received from the Indian Museum, yielded 2 per cent. of succinic acid, while Baltic amber contains from 3 to 8 per cent. In a later paper (**1214**—3) Meyer discusses the question whether

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Burmese amber was exported to the West in ancient times, founding his conjectures on allusions to Indian amber by classical writers. He thinks that it is very probable that amber was among the commodities known to have been brought by Phœnician traders from the East.

The output of the mines naturally varies greatly from year to year, since it depends to a great extent on pure chance, and on the vagaries of an indolent and semi-civilised people. The average annual production, which amounted to 104 cwt. in the five years 1904 to 1908, fell to 29 cwt. in the succeeding five years; while the yearly production varied from 216 cwt. in 1906 to 10 cwt. in 1913. The fluctuations in value are equally great. Thus 126 cwt. produced in 1905 realised £945, while the 216 cwt. of 1906 was valued at only £709. In 1914 the production was 13 cwt., valued at £274, falling in 1915 to 11½ cwt. valued at £199.

Fragments of amber are occasionally found in other parts of Burma, in beds of Miocene age:—

Pakokku.—Grimes (**712**, 54) says that while working in the Yenangyat oil field, two small pieces of amber were brought to him, said to have been obtained from the KYUN KYAUNG, a small stream about 3 miles to the N. of SEIKKWA (21° 8′ : 94° 51′); and in 1852 Piddington described (**1405**—48; —54), under the name of *hircine*, specimens of a mineral resin said to have been found at a considerable depth in the Burmese petroleum wells.

Shwebo.—The discovery of small pieces of fossil resin in a bed of carbonaceous clay underlying a coal seam at MANTHA (22° 54′ : 96° 1′) is recorded by Noetling (**1311**—11, 39). The amber is very brittle, but resembles *burmite* in appearance and specific gravity.

ANTIMONY.

AFGHANISTAN.

GHORBAND VALLEY. Antimony is reported by Lord (**1091**—2, 535) to occur in black slates forming a hill at KINCHAK (35° 3′ : 68° 51′) in the Ghorband valley, and in limestone at FULIGIRD (FARAGARD, 34° 57′ : 68° 52′) in the same district (**Bs** 165).

BALUCHISTAN.

Jhalawan.—SHEKRAN or KAPPAR (27° 53′ : 66° 28′). The lead ore formerly mined on an extensive scale at Shekran (*see* **LEAD, BALUCHISTAN**) contains an appreciable amount of antimony, according to Tipper (**1787**—5). Le Messurier, in a brief account of the mines, published

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in 1844 (**1055**—1), says that the ore occurs in crystals an inch square, with small quantities of lead ore of inferior quality; but he probably refers to galena, for Tipper could find no visible ores of antimony (**B.** 164, 302).

Quetta-Pishin.—KIL 'ABDÚLLA (30° 43′; 66° 38′). Hutton (**900**—8, 599) says that stibnite, accompanied by the white oxide of antimony, valentinite, is said to occur in abundance among the hills to the northward of Kil 'Abdulla (**B.** 164).

BIHAR AND ORISSA.

Hazaribagh.—HISATU (23° 59′ 30″ : 85° 4′ 30″). Specimens of lead ore from the mines at Hisatu (*see* **LEAD, Hazaribagh**) yielded, according to Piddington (**1405**—23, lxv), 17 per cent. of sulphide of antimony, equivalent to 12·2 per cent. of metallic antimony.

BURMA.

Amherst.—According to Helfer (**808**—1, 12) and O'Riley (**1340**—3, 733), sulphide of antimony appears to be generally distributed through the sandstones of the "older formation" of the district, and has been worked to some extent along the range which separates the Maulmein R. from the Ataran. O'Riley (**1340**—4, 168) also says that he discovered several deposits of a rich ore of antimony near the head of the Zimme (Zami) R., the eastern branch of the Ataran. Foley (**595**—4, 272) speaks of antimony having been found in a vein of quartz at a place called GUANGDE (? QUANGADU, 16° 32′ 30″ : 97° 38′, on the north bank of the Salween, opposite Maulmein) (**B.** 166).

Further details are given by Criper (**389**), who describes a quarry opened by O'Riley in search of the ore at LEKKA TAUNG, about 23 miles to the S. of Maulmein. The ore, he says, is in the form of stibnite, and occasionally cervantite, the yellow oxide of antimony. It occurs in pockets in a whitish quartzose sandstone, filling dykes or fissures in the ordinary yellow sandstone of the range, each ore body quickly dying out on all sides, and leaving no trace by which the direction of others may be found. The richest ore is found in the centre of the deposit, and may contain 70 per cent. of metallic antimony. Towards the edges the amount decreases to 2 or 3 per cent. only. Each deposit yields only a few tons of ore. Prospecting operations were in progress at the time this account was written (1885), but apparently met with little success.

Shan States (N).—In the year 1906 specimens of stibnite, largely converted into cervantite, were received at the Geological Survey Office,

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said to have come from a locality situated in Lat. 22° 28′, Long. 96° 34′, in the State of Hsum Hsai (Fermor, **577**—9).

Fragments of stibnite, apparently derived from veins in granite, have also been found in the neighbourhood of NAM HSAN (22° 58′ : 97° 12′), the capital of the Tawng Peng State, but the mineral has not been detected *in situ* (La Touche, **1034**—45, 366).

Burney (**237**—2) and Theobald (**1763**—19, 94) both mention the importation of antimony from the Shan States.

Tavoy.—Low (**1097**—2, 148) states that antimony ore is said to occur in the district (probably in the continuation southwards of the Amherst ranges), but gives no particulars of the deposits.

HYDERABAD.

Karimnagar.—YENCHAPALI (18° 37′ : 80° 23′ 30″). Stibnite is said to have been found in a well-sinking, at a depth of 34 feet from the surface, at Yenchapali or Enchinpilli, in the Nizam's territory (**B.** 164).

MADRAS.

Bellary.—RAMANDRUG (15° 8′ : 76° 32′). Crystals of sulphide of antimony are disseminated among the schists of the Sandur hills, near Ramandrug (Kelsall, **975,** 93), but particulars of its abundance are not stated (**B.** 164).

Cuddapah.—JANGAMRAJPILLI (14° 46′ : 78° 56′ 32″). Antimony is said by Newbold (**1294**—13, 125) to be found in the Nalamalai hills near Jangamrajpilli, the site of a well known lead mine.

Vizagapatam.—KODUR (18° 16′ : 83° 37′). Carmichael (**285,** 155) mentions the occurrence of antimony at this place. Specimens of the ore, exhibited at the Madras exhibition of 1857, are said to have been of good quality (**B.** 164). It had already been shown by Dr. A. Scott (*see* Balfour. **69**—2, 238) that this substance, used as a cosmetic by the natives instead of *surma,* or sulphide of antimony, is really manganese-ore.

MYSORE.

Chitaldroog.—CHIKKANNANAHALLI (14° 24′ : 76° 43′). Cervantite, yielding 52·52 per cent. of antimony, has been found by Sambasiva Iyer (**1548**—5, 116) in a quartz reef on the southern spur of a hill lying to the E. of this place. The extent of the reef has not been determined.

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Kadur.—Ores of antimony are said by Clark (**321**—2, 120) to be abundant in the BABA BUDAN range of hills (13° 30′ : 75° 45′), but the precise localities are not stated (**B.** 164).

NEPAL.

A mineral said to have come from a locality not far from Kathmandu (27° 41′ : 85° 19′) for which the name *nepaulite* was proposed by Piddington (**1405**—57), and supposed by him to contain bismuth, has been determined by Mallet (**1159**—46) as tetrahedrite, containing 25·17 per cent. of antimony. The mineral is said to occur in considerable quantities.

NORTH-WEST FRONTIER PROVINCE.

Kurram.—Agha Abbas (**15,** 613) mentions the existence of a mine of antimony in the ZAIMUKHT HILLS, north of THAL (33° 22′ : 70° 35′) in the Kurram valley. The ore is said to be of inferior quality, but it was exported to Multan.

PUNJAB.

Jhelum.—Antimony is mentioned by Court (**377,** 474) as being mined at KARANGLI HILL (32° 45′ : 73° 5′) in the Salt Range; but the ore is probably galena, which is known to be found there in small quantities (*see* LEAD, **Punjab**). It was sold in the bazaars as *surma*,—the name usually applied to the powdered sulphide of antimony used by Mahomedans for blackening the eyebrows; and no doubt the mistake is to be attributed to this circumstance.

Kangra.—SHIGRI (32° 17′ : 77° 40′). In his account of Kulu, published in 1873, Calvert (**265**—2, 60) claims the discovery of a thick lode of stibnite close to the margin of the Shigri glacier in Lahaul; but the existence of antimony at this locality was known some 20 years previously, for some prospecting work had been carried out by Hay (**792,** 544) before the year 1854, and the discovery was alluded to by Plath (**1410**) in 1856.

In an account of Hay's operations, furnished by an anonymous contributor to the *Madras Spectator*, March 19, 1857 (*see* **35**—2), it is stated on the authority of Marcadieu, who visited the place in 1855, that six lodes or beds of ore are visible, and that specimens assayed by Macnamara yielded 60 per cent. of metallic antimony. As there was no great commercial demand for the metal, Hay proposed that it should be used for making cannon balls, a suggestion that does not appear to have met with the approval of Government.

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Mallet visited the mine in 1864, but says that he did not see the ore *in situ* (**1159**—1, 165). He found loose blocks of ore, which showed that the vein could not be less than 18 ins. wide. Calvert states that the bed discovered by himself was from 10 to 20 ft. thick, and that subsequent exploration showed that the width rose in places to 40 ft. Henwood (**824**—3, 6), who reported on the occurrence in 1886, says that the lode is at least 20 ft. wide, and that it consists of practically solid ore.

The lodes or beds occur in gneiss, and the ore consists of stibnite, superficially altered into cervantite and kermesite, with traces of copper, arsenic, zinc blende, and iron (**B.** 165).

The locality is difficult of access, lying at an altitude of 13,500 ft., beyond the Hamta pass (14,500 ft.), and three days' march from the nearest village in Kulu; while work is possible only during three months in the year. Notwithstanding these obstacles, mining operations were undertaken in 1905 by Col. Renwick, who succeeded in shipping about 15 tons of ore to England (**862**, 233). The experiment, however, does not appear to have been profitable, for no mention of output is made in subsequent returns.

APATITE *see under* **GEM-STONES** *and* **PHOSPHATES—LIME.**

AQUAMARINE *see* **GEM-STONES—BERYL.**

ARSENIC.

In the *Agricultural Ledger* for 1902 (**1903**—3), Sir G. Watt gives a general account of the commercial uses of arsenic and of its occurrence in India. Very little is produced in the country, the bulk of the supply coming in the form of orpiment from China through Burma. The average quantity imported annually in this manner, during the five years 1909 to 1913, was 7,150 cwt.

BENGAL.

Darjeeling.—SAMPTHAR HILL (26° 58′ : 88° 34′). Mallet (**1159**—31, 57) describes an outcrop of arsenical pyrites on the northern flank of Sampthar hill, about half a mile W. 20° S. from the highest summit, at an altitude of about 4,000 ft. The seam is about a foot thick, of which perhaps two-thirds is ore. It contains a considerable proportion of mundic, with a little copper pyrites.

BIHAR AND ORISSA.

Hazaribagh.—DABUR (24° 36′ : 85° 58′) and DHAB (24° 35′ : 85° 50′). Lumps of leucopyrite, an arsenide of iron, weighing several pounds,

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are occasionally found in the mica-bearing pegmatites near Dabur, on the Sukri R., and again about a mile S. S. W. of Dhab (Holland, **859**—37, 51).

KÂSHMIR.

Padar.—BARALI (33° 22′ : 76° 17′). A small outcrop of arsenopyrite was found near the village of Barali in the Bhutna valley, at a height of about 3,000 ft. above the river (La Touche, **1031**—14, 68).

NORTH-WEST FRONTIER PROVINCE.

Chitral.—Orpiment was formerly imported in considerable quantities from Chitral, but of late years the supply has greatly fallen off (**861,** 215). During 1905-06, the latest year for which returns are available, the imports from this source amounted to 10 tons. Nothing is known regarding its mode of occurrence.

UNITED PROVINCES.

Almora.—Traill (**1797**—4, 17) states that yellow arsenic is found at two or three places on the DHARMA and JUWAR or NITI GHATS (passes), but in small quantities only.

MANSIARI (30° 6′ : 80° 19′). Orpiment is collected in small quantities near Mansiari, and is brought down for sale to the Bagesar fair, according to Lawder (**1040**—1, 88) and Atkinson (**48,** 31). The precise locality at which it occurs is not known (**B.** 162).

SHANKALPA GLACIER (30° 20′ : 80° 22′). Cotter and Brown (**373**—2) record the discovery of fragments of orpiment, with a little realgar, on the moraine of the Shankalpa glacier, about a mile above the ice cave. The mineral was not found *in situ*.

ASBESTOS.

AFGHANISTAN.

According to Baden-Powell (**60**—1, Vol. I, 46), asbestos is procurable in considerable quantities among the hills above the KHOST VALLEY (33° 20′ : 70° 0′). It occurs in flat veins or beds, and is said to be used locally for twisting into ropes.

BIHAR AND ORISSA.

Mayurbhanj.—Green actinolite, imbedded in opal, and passing along the borders into fibrous asbestos, was found by Bose (**173**—20, 172) in quartz veins traversing decomposed epidioritic rocks near RANGOM HILL, on the road leading from BETER AMDA (22° 24′ 30″ : 86° 15′) to DUBLABEDA (22° 24′ 30″ : 86° 25′).

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Monghyr.—Sherwill (**1624**—2, 197) mentions the occurrence of thin veins of asbestos in slates on the GORIA KOH GHAT (25° 5′ : 86° 27′), in the Kharakpur hills. In the same paper (p. 204) he says that massive asbestos is reported to be found near the summit of PIRPAHARI HILL (25° 23′ : 86° 34′), 3 miles to the E. of Monghyr.

BOMBAY.

Idar.—DEV MORI (23° 39′ : 73° 28′). Hayden (**793**—26, 73) records the discovery by Middlemiss of a deposit of asbestos, apparently of excellent quality, in the hills S. E. of Dev Mori. When steeped in water and dried, the mineral comes out in long silky masses of beautifully white fibre, some fibres being as much as 8 ins. in length.

BURMA.

Sagaing.—Among some specimens of minerals sent from Ava by Burney, and examined by Prinsep (**1436**—10), was one of fine silky white amianthus, said to be found in a crevice in siliceous dolomite near TSAGAIN (SAGAING, 21° 53′ : 96° 2′).

CENTRAL INDIA AGENCY.

Jobat.—Specimens of asbestos from the Jobat State sent to the Imperial Institute, and examined by Dunstan (**514**—9), were reported to be friable and of short staple, also of inferior colour. It is remarked that the sale of the mineral would not pay the cost of freight.

CENTRAL PROVINCES.

Bhandara.—An output of 18 tons of crude asbestos from a deposit at TUMKHERA KHURD (21° 25′ : 80° 17′) is recorded in the *Quinquennial Review of Mineral Productions* (**861,** 217) as having been obtained in 1908.

MADRAS.

Coimbatore.—In the Coimbatore Manual (**1302,** 24) Nicholson states that asbestos (? chrysotile, the fibrous variety of serpentine) had recently been found near PERANDURAI (11° 17′ : 77° 39′).

Salem.—According to Balfour (**69**—8), asbestos is found abundantly in the Salem district, but it is probable that much of the mineral so-called is in reality chrysotile, which is known to occur with serpentine (**B.** 519).

MYSORE.

Bangalore.—AVILHALLI (12° 57′ : 77° 36′ 30″). Veins of fine white asbestos, traversing a tremolite rock apparently forming a lenticular mass enclosed in granite, were found by Sambasiva Iyer

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(**1548**—8) in a shallow pit near Avilhalli, 2 miles to the W. of Bangalore Fort.

Chitaldroog.—GANGIGERE (13° 44′ : 76° 26′). Fine silky asbestos was found by Sambasiva Iyer (**1548**—5, 115) in cuttings close to the tank at Gangigere in the Hosdurga taluk. The exposure is small, and its value has not been ascertained.

Hassan.—KABBUR (12° 41′ : 76° 21′). Asbestos of fairly good quality occurs in veins traversing actinolite schists here. A considerable amount has been taken out, but operations have ceased (Venkataramaiya, **1838**—2). According to Sampat Iyengar (**1549**—9, 86), the asbestos has been formed by the percolation of meteoric waters along fissures and joints in tremolite schists. The same locality, apparently, is alluded to by Sambasiva Iyer (**1548**—10) as half a mile to the N. of IDEGONDANAHALLI (12° 39′ 30″ : 76° 21′), on the Hole-Narsipur road. He remarks that the mineral occurs at the junction of dunite with gneiss, and that it is white, and soft in texture. An output of 412 cwt. from this district is recorded in 1906 (**861**, 217).

Kadur.—MUDEGERE (13° 8′ : 75° 42′). Sambasiva Iyer (**1548**—10) mentions several localities in the neighbourhood where asbestos is to be found. The most promising deposit occurs near MUDASOSI (13° 9′ : 75° 45′ 30″).

Mysore.—MANDYA (12° 32′ : 76° 57′). Coarse reddish asbestos is found, according to Primrose (**1431**—8, 215), at about 2 or 3 miles S. W. of Mandya, and is sold in the bazaars as a medicine.

NAGAMANGALA (12° 49′ : 76° 49′). Wetherell (**1915**—1, 101) says that small patches of asbestos occur in schists near this place, but not in paying quantities. Veins of coarse asbestos were also found by Primrose (**1431**—1, 22) traversing talcose rocks near KUGANPUR (?).

NORTH-WEST FRONTIER PROVINCE.

Waziristan.—Masson (**1189**—1, Vol. I, 115) states that he has procured specimens of asbestos from KANIGURAM (32° 31′ : 69° 51′) in the Waziri country, but gives no further particulars.

UNITED PROVINCES.

Kumaon.—In a brief notice of asbestos in Kumaon, Stephens (**1694**—3) says that it is found in veins, sometimes 6 ins. in width, in hornblendic rocks near BADHANGARH (30° 1′ : 79° 35′). Also that

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an impure serpentine near PITHAGORA (29° 35′: 80° 16′), when traversed by jade, contains innumerable veins of asbestos, rarely more than ¼ in. wide.

JOSHIMATH (30° 33′: 79° 38′). Stephens (**1694**—3) mentions the occurrence of veins of asbestos, sometimes 4 or 5 ins. in width, traversing serpentinous rocks in this neighbourhood.

UKHIMATH (30° 31′: 79° 9′). A discovery of asbestos, considered to be of good quality, is recorded by Atkinson (**48,** 34) in a hill situated a little to the N. of Ukhimath. It is said to be used by the villagers as a dressing for wounds, and as a wick for oil lamps.

BARYTES.

BALUCHISTAN.

Las Bela.—Concretions of barytes, associated with pyrites, are widely distributed through the Belemnite Shales of the Kalat and Las Bela States, especially on the SARMOWLI R., between Chad and Anjira, and on the lower scarps of the Pab range, near PABNI CHAUKI (25° 17′: 66° 58′). The latter locality is the more favourably situated, as it is only about two days' journey from Karachi. No estimate of the quantity available is possible (Tipper, **1787**—5).

BURMA.

Shan States (N.).—BAWDWIN (23° 7′: 97° 20′ 30″). Large quantities of barytes occur in association with silver-lead ores at the Bawdwin mines in Tawng-Peng State. The mineral was not seen *in situ*, but fragments up to a foot in diameter were found plentifully scattered over a wide area, evidently derived from the outcrop of a large vein (La Touche and Brown, **1035,** 242, 255).

CENTRAL INDIA AGENCY.

Rewah.—BHARRA (24° 23′: 82° 19′). In the "Red Shale" series of the Son valley, a formation of pre-Vindhyan age, veins of barytes from an inch to a foot in thickness were found by Vredenburg (**1325,** 131) near the village of Bharra, on the Mohan R.

Mallet (**1159**—3, 122) mentions the occurrence of thin strings of barytes in lower Rewah beds near SOHAGI GHAT (24° 59′: 81° 46′), and at GINGA HILL, about 40 miles to the S. W. of Allahabad. The deposits are of no commercial value (**B.** 473).

CENTRAL PROVINCES.

Jubbulpore.—SLEEMANABAD (23° 38′ 30″: 80° 19′). Barytes is said to be associated with the lead and copper ores occurring in an outcrop of Bijawar quartzite, about 2 miles to the N. of the railway station at Sleemanabad (**B.** 473).

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In describing an occurrence of fluorite in the metalliferous veins of Sleemanabad, Fermor (**577**—5) mentions barytes as one of the accessory minerals. It appears to exist in considerable quantities, but a consignment sent to Calcutta about the year 1904 was reported to be of poor quality (**862**, 237).

MADRAS.

Kurnool.—GAZULAPALLI (15° 24′ : 78° 40′). Newbold (**1294**—34; —49, 390) states that the galena formerly mined in the Nallamalai hills, 6 miles to the E. of Gazulapalli or Baswapur, occurs in a matrix of barytes, which is found in large masses and nodules, but does not form a true lode. Much of the debris of the old mines consists of this mineral, according to Gopalakristnamah Chetty (**675**, 96), who also mentions (p. 99) that it is found at JALADURGAM (15° 17′ : 77° 57′) and CHANDRAPALLI (15° 13′ : 77° 53′). and at several localities in the Erramalai hills (**B.** 473).

Nellore.—NARRAVADA (14° 54′ : 79° 29′). An outcrop of barytes situated on two low hills about 3 miles to the E. of the village is described by Jones (**953**). It occurs in irregular veins, usually following the strike of the rock, in mica schists, and in minute grains scattered through the schist for some distance on either side of the veins.

Salem.—ALANGAYAM (12° 37′ : 78° 49′). Holland has described in detail (**859**—22) a peculiar and important occurrence of barytes in the neighbourhood of Alangayam. The rocks forming two low hills, lying about a mile S. of the village, consist largely of a network of veins composed entirely of quartz and barytes, traversing porphyritic gneiss. Similar veins are found penetrating the crystalline rocks in the neighbourhood, and have been traced for a distance of 7 miles. The veins vary in thickness from mere strings to dyke-like masses several feet across. They are considered to be intrusions of an igneous rock containing barytes as one of its original constituents.

From the determination of the specific gravity of a large number of specimens, it was found that the average proportion of barytes present in the rock amounts to 30·8 per cent.

PUNJAB.

Simla.—SUBATHU (30° 58′ : 77° 3′). Barytes is said to occur at the lead mines described by Kelly (**974**) and Henwood (**824**—2, 471) in this neighbourhood (**B.** 474).

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RAJPUTANA.

Ajmer.—TARAGARH (26° 27′ : 74° 41′). Barytes is said to be associated with the lead ores formerly mined at this locality (Irvine, **910**—1, 166; **B.** 474).

BASALT *see under* **BUILDING MATERIALS.**

BAUXITE.

The existence of alumina in large proportions in certain laterites of the Central Provinces was first brought to notice by Mallet in the course of a description of the iron ores, etc., of the Jubbulpore district, published in 1883 (**1159**—36, 113); but it was not until after the appearance in 1898 of a paper by Max Bauer (**88**—7) on the laterites of the Seychelles and their relation to bauxite, the principal ore of the metal aluminum, that attention was seriously directed to the possibility of finding a similar connection in India. The credit of the discovery that many of the Indian laterites are in reality bauxites is due to H. and F. J. Warth, who published analyses in 1903 (**1893**) showing that they might be divided into four categories:—(1) a rock consisting of almost pure gibbsite; (2) wocheinites containing gibbsite and diaspore in the proportion of about 3 to 1, with titanium oxide; (3) high level laterites or bauxites, in which the proportion of iron oxide varies with the nature of the rocks on which they rest; and (4) low level or detrital laterites. It should also be mentioned that Holland had, a short time previously (**859**—41), anticipated that the laterites of India and the Seychelles would be found to agree in this respect.

Investigations were promptly set on foot by the Geological Survey for the purpose of ascertaining the distribution and value of the more highly aluminous laterites, and in 1905 the results were published by Holland (**859**—52), with lists of analyses of samples from a number of localities, from which the following table is abstracted:—

——	Al_2O_3	Fe_2O_3	H_2O	SiO_2	TiO_2	CaO	MgO
BIHAR AND ORISSA.							
Kalahandi							
KORLAPAT HILL. (19° 40′ : 83° 14′) .	67·88	4·09	26·47	0·93	1·04	0·36	..
Palamau							
NETURHAT. (23° 28′ : 84° 19′) .	64·64	6·21	24·00	1·79	3·30	0·04	0·02

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——	Al_2O_3	Fe_2O_3	H_2O	SiO_2	TiO_2	CaO	MgO...
BOMBAY.							
Satara							
MAHABLESHWAR. (17° 56′ : 73° 43′) .	50·46	23·41	24·99	0·72	0·42	..	..
Surat							
TURKESAR. (21° 22′ : 73° 7′) .	43·83	26·61	23·88	0·37	4·45	0·86	..
CENTRAL PROVINCES.							
Balaghat							
RUPJHAR. (21° 57′ : 80° 29′) .	51·62	5·51	30·72	0·05	7·51	5·25	..
SAMNAPUR. (21° 58′ : 80° 33′) .	54·20	4·02	27·93	1·55	12·21	..	..
Jubbulpore							
KATNI. (23° 50′ : 80° 28′) .	65·48	3·77	19·38	0·38	11·61	..	trace.
	52·67	7·04	29·83	1·26	7·51	1·75	trace.
BIJEERAGOGARH. (24° 0′ : 80° 41′) .	57·50	6·53	26·94	2·35	6·61	0·15	..
Surguja State . . .	58·23	5·48	28·10	2·01	6·49	0·45	..
MADRAS.							
Madura							
FORT HAMILTON (Palni hills). (10° 6′ : 77° 30′) .	64·34		31·58	4·68	0·95	..	..
KODAIKANAL. (10° 13′ : 77° 33′) .	62·80	0·44	33·74	2·78	0·04	0·20	0·03
	45·77	9·30	28·30	14·58	0·52	..	1·32
Nilgiri hills . . .	38·28	37·88	20·70	3·14	..	..	..
	35·38	34·37	19·00	10·75	0·10	0·40	..
OOTACAMUND. (11° 24′ : 76° 47′) .	31·37	40·18	24·18	2·16	2·01	..	..
Vizagapatam							
GIRLIGUMA. (18° 33′ 30″ : 83° 0′ 30″) .	63·14		16·81	19·32	..	..	..

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In his Presidential Address to the Mining and Geological Institute of India, delivered in 1907 (**859**—64, 31), Holland discusses the prospects of utilising the Indian deposits of bauxite. Though he considers that it would be premature to establish power works in the country for the reduction of aluminium, he thinks that the preparation of the pure calcined oxide for exportation to Europe or America might be carried on at a profit. Accounts of the processes employed in the extraction of the alumina have been given by Dunstan (**514**—19), and by Blake and Crook (**141**).

BOMBAY.

Rewa Kantha (Rajpipla).—Vasna (21° 39′ : 73° 16′). Samples of laterite from this locality have yielded 37·51 per cent. of alumina, and the existence of higher grade varieties is considered possible (Bose, **173**—23, 184).

CENTRAL INDIA AGENCY.

Rewah.—Amarkantak (22° 40′ : 81° 50′). In the talus derived from the laterite capping of the Amarkantak plateau, Fermor observed many blocks of bauxite, often pisolitic and apparently of the best quality. Bauxite of variable quality was also noticed in the laterite of the plateau itself, which extends into the Mandla and Bilaspur districts, Central Provinces (*see* Middlemiss, **1219**—31, 111).

Tonk.—Numerous segregated, rounded masses of richly aluminous laterite were found by Sethu Rama Rau near Konkargarh and Isarwas (24° 8′ : 77° 26′), and again near Kotra and Agra (23° 56′ 30″ : 77° 28′) in the Sironj pargana, imbedded in brecciated and pellety laterite (*see* Holland, **859**—60, 57).

CENTRAL PROVINCES.

Balaghat.—Burton has reported that the laterite, capping outliers of Deccan trap forming the hill masses of Kothi Pat (21° 54′ : 80° 27′) and Tipagarh (22° 2′ : 80° 33′), frequently consists of bauxite of good quality. The laterite reaches a thickness of over 100 feet.

In a report on six samples of laterite from this district, Blake and Crook (**141**) state that they contain from 52·14 to 58·83 per cent. of alumina, and that after calcination the yield would be increased to between 71 and 80·8 per cent.

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Jubbulpore.—Mallet (**1159**—36, 113) mentions a pisolitic variety of laterite, containing a large proportion of alumina, as occurring abundantly among the hills S. of MURWARA (23° 50′ : 80° 27′). He suggests that it might be used if required as a flux in smelting the hematite ores of the district.

Seoni.—Bauxite of good quality has been found by Vinayak Rao on the scarp at AMAGARH (22° 0′ : 79° 40′), and blocks of the mineral were traced for several miles to the south. A representative sample contained 54·78 per cent. of alumina. Near ATARWANI (21° 52′ : 79° 44′) Burton found a small hill containing a deposit of bauxite, estimated to be 20 ft. in thickness, lying between beds of ferruginous laterite (*see* Middlemiss, **1219**—31, 111).

The amount of bauxite produced in the Central Provinces, chiefly by the Katni Cement and Industrial Co. at Katni, was 514 tons in 1914, and 876 tons in 1915.

BERYL *see under* **GEM-STONES.**

BERYLLIUM *see* **RARE MINERALS—GADOLINITE.**

BISMUTH.

Bismuth is not known to occur in commercially valuable quantities in any part of India, but traces of it have been detected at a few localities.

BIHAR AND ORISSA.

Singhbhum.—Ball (**71**—9, 97) mentions that small quantities of bismuth were found in some of the ores from the Singhbhum copper belt.

BURMA.

Amherst.—O'Riley (**1340**—3, 737) states that sulphide of bismuth is said to be found with the ores of antimony occurring in the sandstone ranges between the Ataran and Moulmein rivers.

NEPAL *see under* ANTIMONY.

PUNJAB.

Kangra (Mandi).—Calvert (**265**—2, 11) records the discovery of a small lode of manganese ore with bismuth at THIRRI (SIRHI, 31° 50′ : 77° 14′), on the borders of Kulu (**B.** 163).

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BORAX.

BOMBAY.

Kathiawar.—In the course of a tour through the cotton districts of the Bombay Presidency, in the year 1787, Dr. Hove was informed, when in the neighbourhood of LIMRI (LIMBDI, 22° 34′ : 71° 52′), that borax was extracted from the soil at some place four days' journey distant, and that it was exported to Bombay for the use of the Mint (**873,** 129). No more recent information is available regarding this source of supply (**B.** 498).

KASHMIR.

Rupshu.—PUGA (33° 14′ : 78° 25′). Borax is deposited by the water of a number of hot springs in the Puga valley, and has been collected and exported to India for many years. Marcadieu, who was deputed about the year 1854 to examine the deposits on behalf of some pottery owners in England, says (**1168**—2) that the borax occurs in layers 2 or 3 inches in thickness, associated with an efflorescence of common salt and sulphur. The deposits have been described by Cunningham (**399**—2, 112; —5, 235) as extending for about 2 miles along the banks of the Rulang Chu, the river draining the valley. They have also been described by H. v. Schlagintweit (**1578**—18) in the course of a general account of the occurrences of borax in Tibet.

In 1854 Marcadieu estimated the annual production at 12,000 maunds (whether local or Indian maunds is not stated); but ten years later Stoliczka (**1712**—5, 131) was informed by an official of the Kashmir Government that the output never exceeded 4,000 maunds (probably about 600 cwt., **B.** 498). For the five years 1908 to 1913 the average production was 414 cwt. annually.

RAJPUTANA.

Jaipur.—Samples of salt from the SAMBHAR LAKE (26° 55′ : 75° 15′) contain, according to a rough determination by Warth (**1892**—17, 215), an appreciable proportion of borax, amounting to about ½ per cent. of the dry residue of the brine. He calculates that the waste liquor from the salt works would yield about 500 tons of borax per annum. On the other hand, Holland (**859**—3, 251) states that he failed to detect any trace of boracic acid in the lake brine.

TIBET.

Towards the end of the 18th century, three communications were made to the Royal Society on the subject of the borax or tincal

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deposits of Tibet. The first of these, written in 1786 by Blane (**146**), gives an account derived from Tibetan traders at Bhitauli in Oudh, of a lake of hŏt water surrounded by snowy mountains, situated in the kingdom of JUMLATE, some 30 days' journey to the north. During the winter,—since snow was said to be indispensable to the manufacture,—shallow reservoirs dug in the saline earth were filled with the hot water, from which the borax was deposited on evaporation. Another account, by da Rovato (**419**), an Italian priest resident in Nepal, places the borax fields in the province of MARMÉ, 28 days' journey north of Nepal, and 25 west of Lhasa. Lastly Saunders (**1559—1**, 96) mentions a lake 20 miles in circumference, lying 15 days' journey to the northward of TASHI LHUNPO (SHIGATSE, 29° 18′ : 88° 55′) in Central Tibet. Here the borax was said to be found in large masses in the shallower portions of the lake, and to exist in inexhaustible quantities. The deeper portions of the lake produced salt.

Ngari Khorsum.—In 1848 Strachey (**1716—1**, 348) gave an account of the borax fields of Ngari Khorsum or Hundes, situated to the north of the BONGBWA TAL, beyond the mountains bordering the N. E. side of the Shajjan R. Here the borax, as well as common salt, is obtained by lixiviating the soil on the borders of desiccated lakes. In an abstract of this account by Atkinson (**48**, 33), a description is given of the process of refining the crude borax brought down by the Tibetans to Ramnagar in the Naini Tal district. The borax is steeped in water in shallow pans, and lime is added in the proportion of 2 lb. to about 800 lb. of borax. After being stirred at intervals of 6 hours the mixture is turned out next day to drain on sieves or cloth, and is then dissolved in 2½ times its weight of boiling water, with a further addition of about 16 lb. of lime. The solution is then filtered, and on evaporation is allowed to crystallise in funnel-shaped brass vessels (**B.** 499).

One of the pundits, whose journey was described by Montgomerie in 1870 (**1243—7**, 55), has given further particulars of the borax fields. On his route from RUDOK (33° 23′ : 79° 40′) to the gold fields of THOK JALUNG (32° 8′ : 81° 53′), he passed large deposits of borax at Roksum and the Chak Chaka lakes, and he reports the existence of many fields between Thok Jalung and Lake Manasarowar. Anyone, he says, was allowed to collect borax on payment of a fee of 8*d.* for 10 goat or sheep loads (about 2 cwt.) to the Tibetan authorities.

Statistics of the imports and sale of borax in the early years of the last century are given by Milburn (**1224**, Vol. II, 207) and

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Traill (**1797**—4, 41). They appear to have reached a maximum of about 20,000 maunds (14,000 cwt.) in 1818, but then declined to 5,000 or 6,000 cwt. According to Watt (**1903**—4, 132), the imports from all sources increased from 15,273 cwt. in 1897-98 to 31,085 cwt. in 1901-02. For the five years 1908 to 1913 the average imports were 20,471 cwt. annually.

UNITED PROVINCES.

Warth (**1892**—18) reports that he has detected the presence of borax in samples of "reh" salt from the neighbourhood of ALIGARH (27° 53′ : 78° 8′). The dry extract is said to have yielded 0·1 per cent. of crystallised borax.

BUILDING MATERIALS.

For a general account of the distribution and use of building and ornamental stone in India, reference may be made to a summary of the information available in 1874 drawn up by Ball (**71**—18), and to the chapters on this subject by the same author in the Manual of the Geology of India, Part III (**71**—45, Chaps. XI and XV). Also to an article by Danvers in *Spon's Information for Colonial Engineers* (**417**—2). An abstract of a report by Messent on the granites of India has been published in *The Quarry* (**1212**).

BRICK CLAY.—Clays suitable for the manufacture of bricks are found in all parts of India and Burma, especially in the neighbourhood of the large rivers; but no reliable estimate of the quantity used annually for this purpose is possible, since such returns as are available do not discriminate between clays used for brick making and for the coarser kinds of pottery; nor do they include the complete output of the United Provinces or of Bihar and Orissa, where the consumption of bricks for building purposes must reach very large proportions. For the rest of India, excluding Burma, the average annual production, during the five years 1909 to 1913, is returned as 143,389 tons.

More complete statistics are submitted by the province of Burma, where the average annual output of common brick and pottery clays, for the five years 1909 to 1913, was 579,913 tons.

The following articles, dealing with the manufacture of bricks in India, are published in the Rurki series of Professional Papers on Indian Engineering:—

1865. Anon. (**35**—13). Brick-making in India.
1865. Medley (**1196**). Brickwork in India.
1867. Brown (**209**). Brick-making near Roorkee.

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1872. Tovey (**1792**). On burning bricks with Oopla (dried cowdung).
1874. Falconnet (**564**). On brick and tile manufacture at Allahabad.
1878. Smart (**1650**). On brick making in Burmah.

KANKAR.—A concretionary, nodular form of carbonate of lime, known as *kankar* or *gutin*, is generally distributed throughout the plains of India, especially in the older alluvium of the Ganges and other large rivers. At times it becomes aggregated into solid beds, which have occasionally been used as building stone; but more commonly it has supplied, when burnt, the mortar and cement required for building purposes.

Owing to the manner in which the nodules are segregated, the *kankar* is generally found to contain a proportion of argillaceous matter sufficient to endow the lime with hydraulic properties, and experiments with regard to these have been carried out at various times. The following is a list of papers dealing with this subject:—

1831. Saunders (**1562**). On cements made from (1) *kankar* from the Salt Lakes near Calcutta; (2) *kankar* from Burdwan; (3) Sylhet limestone.
1849. Dickens (**484—1**). On the hydraulic properties of cement made from *kankar* containing 40·05 per cent. $CaCO_3$ and 34 per cent. SiO_2 and Al_2O_3.
1870. Brownlow (**217**). Report on the possibility of making cement in the United Provinces.
1870. Palmer (**1360**). On artificial stone made with *kankar* lime. The best results were obtained by compressing *kankar* nodules and lime in wooden moulds, using a moderate amount of water.
1872. Thomson (**1774—1**). Directions for making analyses of *kankar* and mortar.
1873. Twemlow (**1821**). By slaking *kankar* lime with a 5 per cent. solution of sulphuric acid, a selenitic mortar was produced having double the strength of ordinary mortar, and nearly half that of Portland cement.
1873. Nielly (**1305—2**). Directions for the manufacture of cement from *kankar*, with a table of analyses.
1875. King (**985**). Results of experiments in making briquettes from *kankar* lime.
1877. Nielly, Higham, and Brownlow (**1306**). Report on *kankar* lime and cements used at the Bari Doab Canal works.

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1877. Nielly (**1305**—3). On the correct proportion of water to be used with *kankar* cement.

1878. Dejoux (**453**—5). Notes on the preparation of mortars, cements, and concrete, with an explanation of the processes involved in their setting.

1902. Watt (**1903**—4, 137). A summary of information regarding the principal sources of lime in India, and its industrial uses.

AFGHANISTAN.

Portions of a broad belt of crystalline **limestone** which runs along the crest of the SIAH KOH are worked for **statuary marble** (Griesbach **708**—21, 71). The small quantity of **marble** that has been used for ornamental purposes in Kabul is said to have been brought from MAIDAN (34° 22′ : 68° 52′) to the west of the city (Hayden, **793**—20, 345; —22, 21).

ANDAMAN ISLANDS.

Mallet in 1884 (**1159**—42, 85) called attention to the existence of **limestone** in large quantities at SOUTH CORBYN, near Port Blair (11° 41′ : 92° 43′). Analysis showed that it was equal in purity to the limestone of Katni. A pink variety of this limestone has since been used to a limited extent for decorative purposes at Port Blair (Tipper, **1787**—9, 213); but its value as a building stone is reduced by the numerous veins of calcite which traverse the rock. The lime used in the settlement is obtained from coral reefs (**B.** 470).

Some of the **sandstones** in the South Andaman have been used for building, but are soft and easily weathered (Tipper, *l. c.*).

Ball (**71**—11, 237) suggests that the **serpentines** which are largely developed in the neighbourhood of Port Blair, especially near HOMFRAY'S GHAT, might be used for ornamental purposes.

ASSAM.

Khasi and Jaintia Hills.—For nearly a century the **lime** used for building purposes in Calcutta, and those parts of Lower Bengal where *kankar* is not available, was mainly derived from quarries in a band of nummulitic limestone exposed along the southern face of the Khasi and Jaintia hills. A full account of the distribution of the limestone, and of the manufacture of the lime, has been given by Dr. Oldham (**1326**—8, 134, 180). The stone is not burnt on the spot, but is brought down in boats during the rainy season to villages along the Surma R. in Sylhet, where it is burnt, when the river has fallen, in primitive kilns excavated in the high banks, reeds obtained

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from the numerous *jhils* or swamps of that district being used as fuel (**B.** 469).

The amount of stone quarried is stated by Dr. Oldham in 1854 to have been 60,000 tons annually, on an average of ten years, and the output of lime about 55,000 tons. For the five years 1909 to 1913 the average yearly production of limestone was 96,402 tons. The output in 1914 was 108,431 tons, and 103,736 tons in 1915.

The grey Cretaceous **sandstones** which constitute the plateau of CHERRA PUNJI (25° 17′ : 91° 47′) would furnish an excellent building stone, according to Watson (**1902**—1, 30).

Lakhimpur.—The **lime** used in Upper and Middle Assam has been mainly supplied from boulders and pebbles collected in the beds of the Himalayan torrents (Medlicott, **1197**—9, 412). A list of localities in which **limestone** occurs is given by Hannay (**760**—5 341), who says that a variety from the foot hills between the Dihang R. and Brahmakhund would be suitable for ornamental purposes.

Naga Hills.—**Slates** of good quality are to be found in the Disang series in the valleys of the TUZU and TEPE rivers, and are used in some of the villages for roofing purposes and for whetstones (Pascoe, **1369**—12, 263).

Sibsagar.—A band of shelly **limestone**, probably of lower Siwalik age, and 2 ft. 6 ins. thick, occurs near the hot springs on the NAMBOR R. (26° 24′ : 93° 56′), and has been quarried to some extent for lime-burning and for road-metal (Bigge, **125**—2, 133; Smith, **1657**—2, 87, 92). A similar band crosses the DOIGRUNG, a stream about 4 miles W. of the Nambor, and is here from 5 to 6 ft. thick. It contains about 73 per cent. $CaCO_3$ (La Touche, **1034**—5, 32).

Thick beds of nodular, earthy **limestone**, of nummulitic age, are exposed at the falls on the JAMUNA R. (26° 0′ : 93° 25′), and have been traced along the eastern flanks of the Mikir hills to the village of PANGSO (26° 18′ : 93° 50′), where they appear to die out (Smith, **1657**—2, 81). They are well seen in the valley of the HARIA JAN (26° 4′ : 93° 49′) where they attain a thickness of 300 ft., and in that of the DEOPANI R. (26° 12′ : 93° 53′).

BALUCHISTAN.

Limestones of various ages, from Jurassic to Miocene, are widely distributed throughout Baluchistan (Vredenburg, **1854**—36, 191), and would furnish inexhaustible supplies of excellent building stone and of lime; but the demand for these materials is slight, except in the

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neighbourhood of the Sind-Pishin railway. Cretaceous limestone is used for building purposes at Quetta (Blanford, **148**—73, 232).

BENGAL.

Bankura.—**Quartzites** were at one time quarried at SUSUNIA HILL (23° 24′ : 87° 2′ 30″) on a somewhat extensive scale (Ball, **71**—46, 110). Large quantities have been used in Calcutta for paving, and as copings and curb stones (**B.** 548). This is the stone reported on by Piddington (**1405**—72) as of excellent quality, and comparing favourably as regards the absorption of moisture with Chunar stone.

Burdwan.—Many of the **sandstones** of the Damuda series in the Raniganj coal field would furnish good building material, especially the hard bands in the Raniganj group, the calcareous sandstones in the lower portion of the Talchir group, and some of the beds near the top of the lower Damudas (Blanford, **148**—7, 195). Coarse grained **sandstones** have been quarried at BARAKAR (23° 45′ : 86° 52′) for exportation to Calcutta (Ball, **71**—46, 110), but were found to be incapable of withstanding great pressure (**B.** 546).

Darjeeling.—The building materials available in the Darjeeling district have been fully dealt with by Mallet (**1159**—6, 83—90). **Gneiss,** which is readily split into blocks of convenient size, is used for rubble masonry. **Lime** in inexhaustible quantities might be obtained from the dolomites of the Baxa series, but the actual supply is entirely derived from beds of calcareous tufa. A list of the localities at which these are known to occur is given at p. 88.

Some of the harder **sandstones** of the Tertiary beds would furnish good freestone, but they would require careful selection.

Coarse **slates** are obtainable from the Daling series, but are of small size and too brittle to be easily trimmed (**B.** 467, 555).

BIHAR AND ORISSA.

Cuttack.—**Laterite** is largely used in this district as a building stone, for which purpose it is well adapted on account of the ease with which blocks of any size required may be cut and shaped when the rock is freshly quarried, and its property of hardening when exposed to the air (Righy, **1485**; Blanford, **148**—3; —35, 59). According to Righy, it is procurable over a line extending for about 60 miles in length in a S. W. direction from Cuttack. The superficial layers only, to a depth of 2 or 3 ft., are suitable for building; beyond this depth the rock becomes too soft for use (**B.** 550).

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Lime is manufactured either from shells collected on the sea coast, or from *kankar*, which is mainly obtained from the DEBNADI, to the S. of Cuttack, and other rivers in the delta of the Mahanadi (Righy, **1485**).

Sandstones from the Rajmahal group, occurring at Killah Mootree on the Mahanadi, about 10 miles above the town, are used for cornices and screen work in Cuttack (Righy, *l.c.*).

Gangpur.—Limestones in the Cuddapah series are being worked by the Bisra Stone Lime Co. at BISRA (22° 15′ : 85° 4′) and ROURKELA (22° 13′ : 84° 57′). The average annual output for the five years 1909 to 1913 was 36,496 tons (**862**, 245).

Hazaribagh.—Sandstones from the Talchir group in the Bokaro coal field have been used for building and as paving stones at Hazaribagh (Hughes, **888**—2, 108). They require careful selection, as they are apt to contain silt galls.

Kalahandi.—A short distance E. of KASIPUR (19° 21′ : 83° 11′), the sillimanite schists are traversed by narrow veins of a very fine grained cryptocrystalline aluminous rock, locally known as *lal pathar*, reddish or brownish in colour and soft enough to be cut and carved into small ornaments (Walker, **1872**—3, 21).

Manbhum.—Mallet has described in detail (**1159**—11) two occurrences of **limestone** near the western end of the Raniganj coal field. At BAGHMARA (23° 39′ : 86° 48′) N. W. of Panchet hill, two bands of limestone are exposed in the lower part of the Raniganj group. The upper band contains too much arenaceous matter to be used for making lime, but the lower band, 12 ft. thick, was found to yield on analysis 68·40 per cent. $CaCO_3$ and 14·41 per cent. $MgCO_3$. It had been quarried for use as a flux at the Barakar iron works.

At HANSAPATHAR (23° 38′ : 86° 43′), 6 miles further to the W., the limestone is crystalline and interstratified with gneiss. It is from 70 to over 100 ft. in thickness, and has been traced along the strike for a distance of at least two miles. On analysis it gave 83·43 per cent. $CaCO_3$ (**B.** 371, 458).

Slates of inferior quality are procurable from the sub-metamorphic rocks (Dharwars) in the southern portion of the district (Ball, **71**—46, 112). The cleavage is not sufficiently developed to have obliterated the lamination of the rock, and the slates are therefore apt to break into rhomboidal fragments (**B.** 552).

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Monghyr.—Buchanan-Hamilton in 1831 gave an account of the rocks of the Kharakpur hills, and mentions the quarrying of **hornblendic schist** at LAHETA, 15 miles to the S. of Monghyr, and other localities, both for building and for making quern stones (**222**—19, 35). He also noticed the existence of **slates** in these hills (p. 37).

In his annual report for 1848-49 (**1117**—33, 26), McClelland drew attention to the excellent quality of the **slates** of the Kharakpur hills, and suggested a site midway between GORMAHA (25° 6′ : 86° 23′) and BHIM BHAND (25° 3′ 30″ : 86° 27′) as the best for a quarry. The slates had already been worked on an extensive scale (Sherwill, **1624**—2, 196).

The rock is a slightly metamorphosed phyllite, probably of Dharwarian age, and dips at an angle of about 70 degrees, so that it is conveniently situated for quarrying. The cleavage is not sufficiently developed to give the finest varieties of roofing slate; but fine slabs are procurable and are used for flooring, ceilings, etc. (**862**, 286; **B.** 552).

The average annual output from the quarries now being worked by Messrs. C. T. Ambler & Co., near JAMALPUR (25° 19′ : 86° 33′) was 1,677 tons for the five years 1909 to 1913. In 1915 the output was 2,800 tons.

Palamau.—Bands of crystalline **limestone** of considerable thickness are exposed between the villages of OLHERPAT (OIEYPAT, 23° 50′ : 84° 48′) and DEREDAG, on the eastern edge of the Auranga coal field (Ball, **71**—32, 32). The rock is of great purity, yielding 91·9 per cent. $CaCO_3$. A less pure limestone, with only 60·8 per cent. $CaCO_3$, occurs in great abundance in the Maila R., half a mile E. of SATHBARWA (23° 55′ 30″ : 84° 19′). Some of the Olherpat rock is perfectly white, and could be used as statuary marble (**B.** 459).

Sambalpur.—**Laterite** is commonly used for building at Sambalpur, being preferred to other materials on account of its durability and the facility with which it is wrought (Voysey, **1853**—7, 861).

Limestone bands occur at four distinct horizons in the lower Vindhyan rocks exposed on the banks of the Mahanadi in the neighbourhood of PADAMPUR (21° 45′ : 83° 38′). Limestone also occurs at KUJERMA (22° 0′ : 84° 9′ 30″) to the north, and at BOLANGIR (20° 43′ : 83° 33′) to the south of Sambalpur in metamorphic rocks (Ball, 71—28, 178, 182, 183; **B.** 460).

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Santal Parganas.—Ball (**71**—26, 236) has enumerated the building materials to be found in the Rajmahal hills, and the localities most favourably situated for working them. **Basalt** is widely distributed, and has been used for building temples, forts, etc., not only in the hills themselves, but at places situated at a distance in the plains. Large quantities are also sent to Calcutta for use as road-metal.

Lime is manufactured from beds of calcareous tufa and from *kankar*. The chief deposits of the former occur at MOHWAGARHI HILL (24° 29′ : 87° 27′); in a valley S. of RAJABHITA (24° 41′ : 87° 29′); and between the villages of GONGTI and SIMURTOLA, to the E. of BINDRABUN (25° 1′ : 87° 46′). Tanner (**1744**) has also reported upon a deposit of considerable size at a place called ASURNI (?), where it was known to the natives under the fanciful name of Asurhar, or "Giants' Bones."

Sandstones in considerable variety are obtainable in the northern and southern portions of the hills, from the Damuda series. Some of the intertrappean beds would also supply useful **flagstones**, and have been used for bridge building near BURIO (25° 2′ : 87° 39′) in the centre of the hills.

Shahabad.—A group of thin-bedded **limestones**, occurring in the Vindhyan series at the base of the Kaimur scarp, has been extensively quarried for lime near ROHTASGARH (24° 38′ : 83° 58′) on the banks of the Son R. (Sherwill, **1625**—5, 281). A series of papers by Dejoux (**453**, 1—4) describes the results of experiments on **cement** made from lime and clay obtained from the quarries situated at MARGOHI, 10 miles from Dehri-on-Son. The product is said to have been equal to Portland cement.

The Vindhyan **sandstones** forming the table-land of the Kaimur range in the southern portion of the district have been extensively quarried for building purposes (Martin, **1181**, Vol. I, 510; Sherwill, **1625**—5, 280). The stone is a compact whitish freestone, strong and durable, and has been largely used on the Son irrigation works (**B.** 544).

Singhbhum.—**Slates** of an inferior quality are of common occurrence among the sub-metamorphic rocks, and when polished are occasionally used as writing slates. Some varieties are quite equal in texture to those from the Kharakpur hills in Monghyr (Ball, **71**—46, 127).

BOMBAY.

The **basalts** and intercalated **tuff beds** of the Deccan trap series are so widely distributed throughout the Bombay Presidency that it

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is not necessary to refer in detail to all the localities where they are to be obtained, or have been made use of for building purposes. The composition of the different flows of trap varies greatly, and as Blanford has pointed out (**148**—22, 379), some caution is necessary in selecting those which are most suitable for building. Beds containing strings of zeolites, for instance, are soft, brittle, and liable to decompose. The ash beds are not equal in strength, toughness, or durability to the solid basalts; and no rocks of a red colour should be used, as they are almost always decomposed. The best varieties are the porphyritic basalts, such as those which form a large proportion of the rocks on the THAL GHAT (**B.** 538).

Bell (**99**—1) has written a memorandum on the selection and use of the Deccan basalts, with critical remarks on the native methods of dressing the stone. His paper also includes (p. 169) a statement showing the relative absorption of different varieties of basalt as compared with bricks.

Cowasjee (**379**) has given the results of a series of tests of the comparative strength of Kurla trap and other building stones used in Bombay.

Baroda.—The following building stones and localities are mentioned by Foote (**596**—40, 115—132):

VIRPUR (23° 45′ : 72° 51′). Pale pink and greyish pink **granite**, very tough and durable; moderately coarse; takes a very high polish.

BHULVAN (22° 12′ 30″ : 73° 39′), on the Orsang R. Pale pink and green **granite**; when unweathered should take a high polish.

BHADRALI (22° 13′ 30″: 73° 41′). Black and white **gneiss**; a very handsome stone.

TANDALJA (22° 13′ : 73° 48′). Pale red **felsitic rock.**

MOTIPURA (1 mile N. E. of Bhulvan) } Green, pink, and white
HARIKUA (1 mile S. W. of Bhulvan) } mottled **limestone**, occurring as bands in gneiss. Makes a very beautiful **marble.** Pale brown and cream coloured varieties also occur.

SANDARA (22° 4′ : 73° 39′), on the Heran R. Hard compact **limestones** of various colours; a first class building stone. When brecciated makes a very handsome **marble.**

ACHALI (22° 19′ : 73° 41′)
LACHARAS HILL (22° 7′ : 73° 46′) } **Flaggy quartzite.**
SIHADRA (22° 7′ : 73° 49′)

SANDIA (KUNDIA, 22° 6′ : 73° 44′). **Siliceous breccia**; an extremely hard and dense rock, of red and white colours. Suitable or slabs and pillars.

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SONGIR (22° 6′ : 73° 41′). **Sandstones** of considerable variety as to colour and character of grain. An excellent freestone. Has been quarried on an extensive scale, but without method.

The existence of **slates** of promising quality among the Champaner beds near SURAJPUR (22° 25′ 30″ : 73° 40′ 30″) is mentioned by Blanford (**148**—22, 379).

See also **Kathiawar** *below.*

Belgaum.—A band of **granitoid gneiss** to the S. of Belgaum, between GANIBAIL (15° 41′ : 74° 34′ 30″) and KHANAPUR (15° 38′ : 74° 34′), would furnish building stone of excellent quality, according to Foote (**596**—12, 257).

Bijapur.—In a memoir on the geology of the S. Mahratta country (**596**—12), Foote mentions the following localities in this district where building stone is procurable :—

BIJAPUR (16° 50 : 75° 47′). **Basalt** has been extensively used for old buildings in the town (p. 266). Newbold (**1294**—24, 946) remarks that the stone is very uneven in quality.

BILGI (16° 21′ : 75° 41′). A red and green variety of porphyritic **granitoid gneiss** occurs here (p. 257). Hard **quartzite** from the overlying Kaladgi series has also been quarried (p. 261).

KALADGI (16° 12′ : 75° 34′). A great variety of **limestones,** banded in pink, green, purple, and grey to black colours, occurs in the immediate neighbourhood of the town (p. 116). These belong to the lower Kaladgi series.

UGUNI (16° 34′ : 76° 32′).
CHANNUR (16° 29′ : 76° 37′).
MAILESHWAR (16° 28′ : 76° 24′).
} Pale drab and cream coloured **limestones** belonging to the Bhima series are quarried at these places, and are much esteemed, especially the cream coloured variety (p. 154).

AIHOLI (IWULEE, 16° 1′ : 75° 57′). Fine cream coloured and reddish yellow brown **sandstones** have been extensively quarried for ancient buildings, and are of excellent quality (p. 260).

GUDUR (15° 56′ : 75° 58′ 30″)
PARVATI (16° 2′ : 75° 51′)
} Thick bedded **sandstones** occurring at these places are well worth attention (p. 262). Newbold (**1294**—24, 948) also mentions that a bed of sandstone underlying trap at ALKOPUR (16° 28′ : 76° 6′) is much used for building.

HALIGERI (16° 0′ : 75° 32′).—Fine **flagstones** are procurable here, and have been extensively quarried (p. 262).

The **schists** of the Dharwar series are much used for rough purposes. The town of HUNUGUND (16° 4′ : 76° 8′) is entirely built

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of poor hematite schist from Hunugund hill (p. 258). Newbold (**1294**—23, 935) says that long slabs of **hornblende schist** obtained from ravines on the banks of the Kistna R. near DHANUR (16° 11′ : 76° 9′) are used for building.

The existence of **slates** among the rocks of the Kaladgi series has been noticed by several writers. Jervis in 1832 (**944**—1) stated that the finest description of roofing slate was procurable at LOKAPUR (16° 10′ : 75° 26′). His opinion was afterwards corroborated by Newbold (**1294**—20, 18; —41, 274), who mentions the occurrence of good slates at SILLIKERI (16° 9′ : 75° 35′) near Kaladgi; and by Rigby (**1484**—1), who says that fine slates are quarried in the neighbourhood of TALIKOTA (16° 28′ : 76° 22′), and that the town is entirely built of this stone. On the other hand, Foote (**596**—12, 262) describes the slates of Sillikeri as being merely hard, thin shales, and says that they were found not to answer well as roofing slate.

Cutch.—The building stones of this district have been described by Wynne (**1975**—11, 91-94).

The **limestones** of the lower Jurassic group furnish good black and grey, or orange stone. The former is procurable in the hill ranges along the coast N. of BHUJ (23° 15′ : 69° 44′); and the latter occurs in quantity at RAIMALRU HILL near KAORA (23° 50′ : 69° 45′), in Patcham I.

A red or yellow, thin bedded, calcareous rock occurring in the same group in PATCHAM I., largely composed of broken shells, is susceptible of a good polish, and is known as **Dokawana marble.**

Sub-recent **concrete**, or coarse soft calcareous **sandstone**, closely resembling the "**Porbandar stone**" of Kathiawar, is largely quarried on the *ghat* descending from the CHARWAR RANGE S. W. of Bhuj and elsewhere. The stone has a fine white colour, and hardens on exposure to the air.

Sandstones are plentiful and are extensively used. The best varieties are furnished by the lower Jurassic group. Those from the upper Tertiary beds are soft, and when they contain salt are liable to rapid decay.

Dharwar.—Foote (**596**—11, 134) mentions the occurrence at DHONI (15° 17′ 30″ : 75° 47′) of grey and greenish grey crystalline **limestone**, in beds of considerable thickness, which would yield a building stone of great beauty and excellence.

Chloritic schists have been used for building the famous temples at GADAG (15° 26′ : 75° 42′), and are susceptible of being most elaborately and delicately carved (Foote, **596**—12, 258).

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Idar.—The **sandstone** quarries of AHMEDNAGAR (23° 36′ : 73° 1′) yield an excellent freestone. **Marble** and **granite** may also be obtained in any quantity (Hayden, **793**—26, 83).

Kathiawar.—The following building stones are mentioned by Fedden (**569**—6, 134-136) :—

A finely colitic and highly organic, porous **limestone**, known as "**miliolite**," or more commonly as "**Porbandar stone**," from the name of the port whence it is shipped to Bombay and other places, is extensively quarried along the western base of the BARDA HILLS, especially in the neighbourhood of RANPUR (21° 50′ : 69° 45′). The stone is of a fine white or buff colour, very obliquely laminated, and is easily worked. The refuse chips and rubble are burnt for lime, which is said to be of excellent quality.

A full account of the mode of occurrence and character of the rock has been given by Evans (**555**—7, 561).

Artificial stone made from powdered Porbandar stone and sand from dunes on the coast of Cutch is described by Pye-Smith (**1444**) as having given good results.

White mottled hard **marble**, consisting of a mixture of aragonite and calcite, occurs at the villages of KHIRASRA (21° 57′ : 70° 22′) and SAJRIALA (21° 56′ : 70° 37′), forming an irregular vein not more than 30 ins. in width in trap rocks. The stone is capable of a high polish, but is found only in limited quantities.

Light coloured kaolinic **sandstones** of upper Jurassic age occur in the neighbourhood of DHRANGADRA (23° 0′ : 71° 32′), where there are extensive quarries. The stone is much esteemed for building purposes, and has occasionally been exported beyond the limits of the district.

A bed of **sandstone** of remarkably fine texture is quarried at BAOLI (22° 56′ : 71° 27′ 30″), and is used as a whetstone or for ornamental purposes, also for making cups, pipe bowls, etc.

(Baroda). Foote (**596**—40, 172-180) mentions the following building stones as occurring in the portions of Kathiawar which belong to the Baroda State :—

Basalt is quarried on a large scale at AMRELI (21° 36′ : 71° 16′) and GAODKA (21° 32′ 30″ : 71° 13′).

A dyke of **porphyritic diorite** near RUPAVATI (21° 11′ : 71° 8′) would yield a very handsome stone. It is of a blackish colour, with felspathic grains of a warm green tint.

Dykes of light coloured **acidic trap** occur at DAMNAGAR (21° 42′ : 71° 35′), SAKHPUR (21° 33′ : 71° 34′ 30″), and DHALKANIA (21°

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14′ 30″ : 70° 59′). The stone is suitable for high class buildings, but has only been quarried at Damnagar.

A **calcite** vein occurring near PIPALWA (21° 7′ 30″ : 71° 15′) would yield a handsome **marble** of mottled white and grey colour.

"**Miliolite**" of equal quality with that of the Barda hills occurs in inexhaustible quantities in the neighbourhood of KODINAR (20° 47′ 30″ : 70° 46′).

A brown flaggy **limestone** occurring at SHEDAYA (20° 53′ : 70° 51′) is said to be worthy of attention.

The brecciated **limestone** found at and to the S. of RAJPURA BANDAR (22° 24′ : 69° 9′) is a strong fine grained grey stone of pleasing appearance.

A dense shelly **limestone** occurring near BARDIA (22° 12′: 69° 5′) would form a **marble** suitable for decorative purposes. It is of a pinkish yellow colour.

(**Navanagar**).—Adye has recently given (**11**, 132, 150, 232) an exhaustive account of the mode of occurrence and origin of the "**miliolite**" **limestones** of the Navanagar State, together with notes on the distribution and economic value of the stone.

The following building stones are also described by Adye:—

Felsites and **granophyres** (p. 186). These occur in great abundance in the BARDA (21° 50′ : 69° 50′) and ALECH (21° 50′ : 70° 0′) hills. The stone is fine grained and tough, of whitish and greyish colours when fresh, and is excellently suited for ordinary building or for ornamental purposes.

Habardilite (p. 203). A hard conglomerate composed of pebbles of laterite cemented by calcite, taking a good polish. It occurs in beds 4 to 6 ft. in thickness at HABARDI HILL (22° 13′ 30″ : 69° 26′).

Palagonite (p. 100). Bands of a dense black or green structureless stone, susceptible of a high polish, and occurring in blocks from 4 to 6 ins. in thickness, were observed on the rising ground about a mile to W. of RANINGPUR (22° 14′ 30″ : 71° 8′ 30″).

Pindaralite (p. 176). A finely-textured fossiliferous limestone, occurring in the Gaj group at PINDARA (22° 15′ : 69° 19′). The stone is of a yellow or orange brown colour, becoming red when sun-baked, and is suitable for architectural work of every description. At Pindara and other places in the neighbourhood it forms a bed about 2 ft. in thickness.

Ramwaralite (p. 183). A dolomitized variety of Pindaralite, occurring as a bed 2 to 3 ft. in thickness in the RAMWARA STREAM, 2½ miles to E. N. E. of the village of GURGAT (22° 12′ : 69° 15′). The stone is soft when quarried, but rapidly hardens on exposure.

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Rewa Kantha (Rajpipla).—Bose (**173**—23, 186) mentions the following building stones as worthy of attention :—

Marbles varying in colour from black to greenish and white occur in the Bagh beds, in layers from 2 or 3 ins. to as many feet in thickness. The black varieties take a good polish. They are exposed at the following localities :—

A mile S. E. of GORA (21° 52′ : 73° 45′).

ZULTA AMDA and VANJI (21° 54′ : 73° 52′).

MOKHADI (21° 49′ : 73° 48′).

TODAKHAIL STREAM (21° 47′ : 73° 52′). These are the most extensive deposits.

Quartzitic sandstones well suited for building purposes are found in all the outcrops of the Bagh beds. They have been quarried at SAKVA (21° 51′ : 73° 40′ 30″). Massive **sandstones** belonging to this group exposed along the Deva R. would furnish excellent material, according to Blanford (**148**—22, 380).

The best stone for ordinary purposes (Bose, *l.c.*, 187) is a **trachytic rock** intrusive in the Deccan trap. It is a greyish white, moderately hard, massive rock, and takes a fairly good polish. Outcrops of the stone occur in KARIA HILL (21° 41′ : 73° 20′), 7 miles from the railway at Rajpardi, and in BARDARIA HILL near UNDI (21° 40′ : 73° 23′ 30″).

Bedded **tuffs** in the Deccan trap series have been used for building temples at RAJPIPLA (21° 47′ : 73° 37′). They also occur to the S. of SAMARIA and MOTA AMBA (21° 51′ : 73° 40″).

Sind.—Limestones for building purposes are procured from the Ranikot, Khirthar, and Gaj beds, all of which also furnish excellent lime. The best variety of limestone is perhaps that found at JHIRAK (25° 3′ : 68° 19′). It is a light yellowish brown, fine grained rock, derived from the Ranikot beds. At Karachi a whitish, rather porous limestone from the Gaj beds, resembling the 'Calcaire grossier' of Paris, is extensively used (Blanford, **148**—63, 194).

Merewether (**1206**—2) and Price (**1429**) have described the results of experiments in preparing **cement** and **concrete** from hydraulic lime made locally, and sand or clay brought from the bed of the Lyari R., during the construction of the Karachi Harbour works. The use of salt water was found to add to the strength of the cement, but it was inferior to Portland cement.

Barns (**79**—3) has also given examples of the excellence of hydraulic **cement** made with lime from the Khirthar beds at SUKKUR (27° 42′ : 68° 55′) and *surki*, or powdered bricks.

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Sandstones of good quality might be obtained from the lower beds of the Nari group. Those from the Manchar beds (upper Tertiary) are usually too soft for the purpose (Blanford, **148**—63, 194).

Surat.—Nummulitic **limestone** occurs in great quantities around TARKESHWAR (21° 22′ : 73° 7′), to the N. E. of Surat (Blanford, **148**—22, 379). A list of the building materials obtainable in the district is given in the *Bombay Gazetteer*, Vol. II, p. 38.

Thana.—The varieties of **basalt** which have been found most suitable for building purposes in Bombay are mentioned by Carter (**288**—8, 208).

A considerable proportion of the **lime** used in Bombay is derived, according to Buist (**228**—17, 16), from deposits of shelly sandstone or littoral concrete found on VESAVA ISLAND (19° 9′ : 72° 52′). The results of a series of tests carried out in order to determine the strength of mortars and concretes made in Bombay have been given by Chadwick (**299**).

BURMA.

Amherst.—Limestones occur abundantly in the neighbourhood of MAULMEIN (16° 30′ : 97° 40′), and would furnish unlimited supplies of building stone and lime (Low, **1097**—2, 156). Some of these rocks are capable of taking a high polish, but the numerous veins of calcite which traverse the stone render it brittle when cut into flooring slabs (O'Riley, **1340**—3, 743).

Bassein.—A band of **limestone** 30 to 40 ft. thick occurs near the Bassein R. to the S. of THAMANDEWA (16° 23′ : 94° 42′), and has been traced for a distance of at least two miles. The quality is said to be good, and the locality is easily accessible by water. Large deposits of limestone also occur at BANMI (17° 19′ : 94° 41′), on the western coast of Arakan. The rock is a very pure carbonate of lime, containing 96·4 per cent. $CaCO_3$ (Theobald, **1763**—16, 344, 345; **B.** 470).

A soft calcareous sandy rock, resembling in some respects the "**Porbandar stone**" of Kathiawar, occurring in abundance on KORANGYI I. (16° 31′ : 94° 17′) and the adjoining mainland, is highly recommended by Theobald (**1763**—16, 340) for trial as a building stone. The deposits exist in a position very favourable for working, as the stone could be loaded into vessels under the lee of the island.

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Kyaukpyu.—**Limestone** occurs at several localities along the eastern side of RAMRI I. (Mallet, **1159**—14, 221). The most important deposit was found to the N. of YANTHEK (19° 8′ : 93° 56′), where it is continuous over an area of many acres, close to a tidal creek. The stone contains 94·4 per cent. $CaCO_3$ (**B.** 470).

Mandalay.—A chocolate coloured **limestone** of Ordovician age has been quarried near ZEBINGYI (21° 53′ : 96° 21′), on the ascent to the Shan plateau, and sent to Rangoon for use in the building of the Government Hospital. Large quantities of **lime** are manufactured at TONBO (21° 53′ : 96° 15′) near the foot of the hills, and at Zebingyi, from limestones of Carboniferous and Silurian age (La Touche, **1034**—45, 375).

The SAGYIN HILLS (22° 17′ : 96° 7′), 20 miles N. of Mandalay, are to a great extent composed of a beautiful white **marble**, much esteemed by the Burmese, and used to a certain extent for ornamental screen work, but mainly for carving images of the Buddha, many of them of colossal size. The stone is brought down the Irrawaddy in boats to Sagaing, where it is worked into shape. Full details of the process of quarrying, dressing, and polishing the marble have been given by Oldham (**1326**—17, 326).

Marble of a similar kind, often banded with grey, occurs in unlimited quantities at KYAUKSÉ (21° 37′ : 96° 11′), to the S. of Mandalay. Enormously thick bands of the same crystalline **limestone** extend across the Ruby Mines district, from THABEIKKYIN (22° 53′ : 96° 1′) on the Irrawaddy to and beyond MOGÔK (22° 55′ : 96° 33′). Here, however, the texture of the stone is usually much inferior to that of the Sagyin marble (La Touche, **1034**—45, 376).

Shan States (N.).—The dolomitic **limestones** which cover a very large portion of the Shan plateau are almost invariably in so thoroughly crushed a condition that they are useless for building purposes, and are only fit for supplying road-metal for local needs. A highly fossiliferous band of middle Devonian age, occurring at PADAUKPIN (22° 6′ : 96° 39′ 30″), near Wetwin railway station, would yield a very handsome **marble**, being capable of a high polish. The **limestones** of Permo-Carboniferous age, overlying the dolomites, also take a good polish, but the known exposures of these rocks lie at a considerable distance from the railway, and are not likely to be in demand.

Some of the harder bands among the **sandstones** of Jurassic age, (Namyau series), which are strongly developed in the eastern portion of the Shan plateau, would yield excellent building stone; but so

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far there has only been a limited local demand for this purpose in connection with the railway. Sandstones quarried near HSIPAW (22° 37′ : 97° 20′ 30″) have been used for the piers of a bridge over the Nam Tu at that place, and were found to answer well (La Touche, **1034**—45, 375).

Thaton.—Since the year 1907 there has been a large output of **granitoid gneiss** from quarries situated at the base of the scarp of the Shan hills E. of the Sittaung R. (*see* La Touche, **1034**—39, 100). The stone has been extensively used by the Burma Railways Co. and on the Town Lands Reclamation Works in Rangoon, about 300,000 tons having been raised annually.

Quarries were opened in 1909 on KALAGAUK I. in order to supply similar stone for the Rangoon River Training scheme. The output reached a total of 295,125 tons in 1912, but on the completion of the scheme in 1914 the quarries were closed (**862**, 243).

Thayetmyo.—**Limestone** is of common occurrence along the eastern base of the Arakan Yoma, but the most accessible locality is near THAYETMYO (19° 19′ : 95° 14′), where a band of nummulitic limestone, forming a hill to the S. of the town has been extensively quarried for lime burning (Theobald, **1763**—16, 344). Ranking (**1458**, 58) says that the lime makes excellent cement, but is not hydraulic.

Toungoo.—**Sandstone** quarries near TOUNGOO (18° 55′ : 96° 28′) were examined and reported on by Cotter (*see* La Touche, **1034**—39, 101) in 1909. The stone is of two qualities:—(1) Yellow calcareous sandstone from 200 to 300 ft. thick, exposed for about a mile; soft when freshly cut, but hardens on exposure. (2) Purple and pink sandstone of medium grain, harder than the yellow stone; occurring in layers averaging about 6 ins. in thickness.

CENTRAL INDIA AGENCY.

Both **limestones** and **sandstones** of excellent quality for building purposes are procurable in any desired quantity from the several members of the Vindhyan System, which occupies an area very nearly coinciding with that included in the political boundaries of the Agency, except in the south and west, where it is concealed to a great extent beneath a covering of Deccan trap. The general distribution of the Vindhyan rocks has been described by Mallet (**1159**—3), and their development in special areas by the following writers:—

Bundelkhand: Medlicott (**1197**—2).

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Panna State: Vredenburg (**1854**—17).
Rewah, Son Valley: Oldham, Datta, and Vredenburg (**1325**).

The best varieties of **sandstone** are furnished by the Kaimur group, the lowest member of the upper Vindhyans. They are usually fine grained, of white and pale buff or reddish colours, and occur both in massive beds free from joints and fissures, and in flaggy layers which may be used as flooring slabs. The stone from the overlying Rewah and lower Bhander groups is usually more harsh and gritty in texture, and of a darker red colour; but some of the finest building stone in India is quarried locally from the upper Bhander stage (Mallet, **1159**—3, 116).

Gwalior.—Cunningham (**399**—4) has given the results of experiments in testing the strength of beams cut from Vindhyan sandstones occurring in the neighbourhood of Gwalior.

The existence of **slates** of fair quality in the Bijawar series near BAGH (22° 21′ 30″ : 74° 51′), in the Amjhera division of Gwalior State, has been noticed by Blanford (**148**—22, 379) and Bose (**173**—5, 14). These slates have since been favourably reported on by Jones (*see* Hayden, **793**—26, 84).

Indore.—Bose (**173**—5, 70-72) mentions the chief building stones procurable in the neighbourhood of the Narbada R. The finest variety is a **coralline limestone** of upper Cretaceous age, which furnishes a handsome **marble**, capable of a high polish. It was formerly quarried at BOWARLA and KHERWAN (22° 19′ : 75° 15′), and at CHIRAKHAN (22° 22′ 30″ : 75° 11′), and employed in the construction of temples and palaces at Mandhata and Mandu. An outcrop also occurs to the W. of BARWAI (22° 15′ : 76° 6′), but here the rock is rather coarse and thin-bedded, and has not been worked to any extent.

Sandstones of excellent quality may be obtained from exposures of Gondwana rocks. Quarries have been worked at GHATIA and RUPABARI near Barwai, and on an extensive scale near KATKUT (22° 25′ : 76° 10′). The stone is durable and soft enough to be carved with facility.

Rewah.—Large quantities of **limestone** are raised at SUTNA (24° 34′ : 80° 53′ 30″) by the Sutna Lime and Stone Co. The average annual output for the five years 1909 to 1913 was:—Limestone, 34,218 tons: Unslaked lime, 18,695 tons: slaked lime 1,818 tons; stone sets, 56,283, pieces. Much of the limestone is sent to the Barakar Iron Works for use as flux.

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Hughes (888—29, 220) mentions the following sources of limestone in the neighbourhood of the Umaria coal-field :—

		Average composition.			
		$CaCO_3$	$MgCO_3$	$Fe_2O_3 + Al_2O_3$	Insoluble.
Bodri (23° 10′ : 81° 30′) .	Lameta limest .	86·50	5·60	0·60	5·90
Jhapi (23° 27′ : 80° 39′ 30″) .	Bijawar limest .	51·60	32·75	0·75	14·90
Kalesar (23° 31′ : 80° 54′) .	Kankar . .	71·40	3·55	4·95	20·10
Karimati (23° 29′ 30″ : 80° 53′)	Tufa . .	95·20	2·10	1·05	1·65
Majgama (23° 33′ : 80° 50′) .	Metamorphic limest.	73·40	17·75	0·90	7·95

The Barakar sandstones of the Umaria coal field are soft when freshly quarried, but become harder on exposure to the air. Excellent material is said to be procurable between Kirintal (23° 30′ : 80° 55′) and Amha (23° 29′ 30″ : 80° 57′), beyond the limits of the coal field.

CENTRAL PROVINCES.

Amraoti.—Blanford (148—22, 380) notes the occurrence of good strong **sandstone**, free from joints, near Ellichpur (21° 15′ : 77° 35′), at the base of the southern scarp of the Gawilgarh hills (*see also* p. 277).

Betul.—Patches of crystalline **limestone** occur among the metamorphic rocks on the edge of the Pench Valley coal field between Bakar (22° 4′ : 78° 12′) and Enkawari (22° 3′ : 78° 4′). Lime could also be made from calcareous nodules occurring in the Motur group.

Fine white **sandstones** are quarried at Sirgora (22° 12′ : 78° 57′), and at Pathé (22° 10′ : 77° 56′ 30″) from the Talchir group (Jones, 952—3, 57).

Chanda.—Good **limestone** may be obtained both from the Vindhyan and Lameta groups. The most accessible outcrop of the former is at Kandara (20° 18′ : 79° 3′), and of the latter at Karamgohan (20° 12′ : 79° 2′ 30″).

The Kamthi group in the Wardha Valley coal field affords **sandstones** suitable for all sorts of building purposes. Excellent stone may be obtained at Bhutara hill (20° 20′ : 79° 8′ 30″).

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It is soft and easily dressed when first quarried, but hardens on exposure. A compact pink argillaceous sandstone occurring at ISAPUR (19° 53′ : 79° 23′) is capable of being carved into the finest tracery work (Hughes, **888**—20, 112-115).

Hoshangabad.—Limestone occurring in the Bijawar series, when not chert-banded, has been employed for building temples, as near KHUDIA (22° 14′ : 76° 47′), but it is usually too hard to be worked with ease.

Bijawar **sandstone** has been extensively quarried at CHIRAKHAN (22° 26′ : 76° 55′ 30″), and used for building the fort at Juga, as well as temples in the neighbourhood. The stone is coarse and hard, and but little prized (Bose, **173**—5, 70).

Thin red **sandstone flags** from the Rewah group near HOSHANGABAD (22° 45′ : 77° 47′) are used as roofing tiles (Mallet, **1159**—3, 117).

Jubbulpore.—A band of **limestone** of lower Vindhyan age is extensively quarried at KATNI (23° 50′ : 80° 28′) by Messrs. Cook & Sons and others. The average annual output for the five years 1909 to 1913 was 78,240 tons. According to Mallet (**1159**—36, 111), much of the limestone is of inferior quality. The best variety, containing 94·65 per cent. $CaCO_3$, occurs in thin beds aggregating only some 10 ft. in thickness.

White crystalline **marble** occurs in immense quantities at the picturesque gorge known as the "MARBLE ROCKS" (23° 7′ : 79° 51′) on the Narbada R. near Jubbulpore, but it has not been worked to any extent.

Nagpur.—Basalt from the Deccan trap series has been quarried for many years at SITABALDI HILL (21° 9′ : 79° 8′) near Nagpur.

A hard dolomitic **limestone** occurring at KHORARI (21° 15′ : 79° 10′) is occasionally quarried and carved into images, etc., (Jenkins, **938**—1, 198).

The Kamthi **sandstones** exposed in the neighbourhood of Nagpur furnish large supplies of excellent building stone. The quarries at SILEWADA (21° 17′ 30″ : 79° 11′) have been described in detail by Blanford (**148**—33, 310). They yield several varieties of material, from compact yellow or buff shale used for ornamental purposes to more or less fine grained sandstone of white and purplish colours.

MacGeorge (**1122**) gives the results of crushing tests of Kamthi sandstones, carried out in London. The hardness and solidity of the stone were found to increase considerably with lapse of time

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after being quarried. The average crushing strain was 1,500 lb. per square inch.

Nimar.—According to Bose (**173**—5, 71), **sandstone** of excellent quality has been quarried from an exposure of Gondwana rocks at AKHUND (22° 10′ 30″ : 76° 16′). It has been employed in building the fort and temples at Punassa, and for the railway bridge over the Narbada at Mortaka.

Raipur.—Bose has reported that the Chandarpur sandstones, of lower Vindhyan age, occurring along the southern edge of the Chhatisgarh plain, yield good building stone in places (*see* Griesbach, **708**—31, 39).

HYDERABAD.

Bidar.—Laterite has been extensively employed as a building stone in the town of BIDAR (17° 55′ : 77° 36′). The sectile beds used for the purpose lie at a considerable depth from the surface (Newbold, **1294**—18 ; —32, 994).

Gulbarga.—An extremely handsome variety of **granitoid gneiss**, containing much epidote (pistacite) in lieu of mica or hornblende, occurs in large quantities in the bed of the Bhima R. between LINGARY and KUMUNUR (16° 37′ : 77° 14′), and again near GAGULU (16° 28′ : 77° 12′ 30″), on the S. bank of the Kistna R. (Foote, **596**—12, 257).

Nalgonda.—Thin bedded **limestones** belonging to the Kurnool series are exposed along the left bank of the Kistna R., and afford serviceable building stone, besides being burnt for lime (Walker, **1868**—5, 187).

Raichur.—Basaltic diorite from a large dyke at GUTT BICHAL (15° 59′ : 77° 22′) has been used in the construction of the railway bridge over the Tangabhadra R. at KASAPUR (Foote, **596**—12, 259). The rock is extremely hard and tough, and is jointed in such a manner that blocks of a convenient size for building may be extracted.

A beautiful variety of rather fine grained, pale grey **granitoid gneiss** occurs in a low hill at GOBUR (16° 19′ : 77° 13′). Several unfinished Jain temples in the neighbourhood are built of it, and show no trace of weathering. Red porphyritic **granitoid gneiss** occurs at JALDRUG (16° 15′ : 76° 29′) on the Kistna R. ; and a red and green syenitic variety at GAJENDRAGARH (GUDJUNTURGURH, 15° 44′ : 76° 2′). An exceedingly handsome red **syenitic** rock, capable of a high polish, forms the high hill W. of MOSULAKAL (16° 23′ :

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77° 4′), and could be quarried in large masses, the jointing being favourable (Foote, **596**—12, 256).

Sandstones in the Kaladgi series have been largely quarried at HANAMSAGAR (15° 52′ : 76° 6′), and are fine enough to be used for elaborate carvings and mouldings (Foote, **596**—12, 260).

KASHMIR.

The amygdaloid **basalts** of the Takht-i-Suleiman and other hills in the neighbourhood of SRINAGAR (34° 5′ : 74° 54′) furnish an abundant supply of hard and durable building stone.

Cunningham (**399**—5, 230) says that the fossiliferous **limestones** of the Kashmir valley are capable of a high polish, and would yield a handsome **marble**. These limestones range in age from lower Carboniferous to Trias, and are widely distributed among the hills lying between Srinagar and the Lidar valley (Middlemiss, **1219**—28, 217).

MADRAS.

The crystalline rocks which are almost everywhere to be found throughout southern India, including **charnockites, granitoid gneisses, granite,** and **marble,** afford a great variety of excellent building stones, a circumstance of which the ancient temple and palace builders fully availed themselves, as numerous fine examples of their art still bear witness. The characters and general distribution of the **charnockites,** a series of hypersthene-bearing rocks of Archæan age, have been specially described by Holland (**859**—31); while a general account of the varieties of **granite** found in the Presidency has been compiled by Newbold (**1294**—27).

The peculiar method adopted by the natives of southern India for quarrying the granitoid rocks, in which advantage is taken of the exfoliation caused by expansion of the rock when heated, has been described by Benza (**110**—2, 9), Newbold (**1294**—27), Campbell (**272**—10, 171), Blanford (**147**—8, 202), and Warth (**1892**—22). Small fires are lighted on the exposed surface of the rock in a line parallel to the free edge of the outcrop, and are gradually moved forward and elongated as the rock is split by the expansion of the outer layers, the progress of the fissure being detected by the change in the sound given out by the rock when tapped with a hammer. In this manner sheets of stone measuring in some cases as much as 2,000 sq. ft. in area, and not more than 6 ins. in thickness, can be detached. These are afterwards broken up by means of wedges into blocks of the size required.

The native method of polishing the stone has been described by Kennedy (**978,** 1—3).

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Laterite is found in most parts of the Presidency, and is commonly used in building. Babington in 1819 (**55**, 330) described the method of quarrying the rock, and a peculiarly shaped axe employed for trimming the stone into shape. A general account of the occurrence and use of laterite has also been given by Cole (**336**—1), Clark (**321**—1), Newbold (**1294**—38, 227), and Blanford (**147**—8, 150).

A full description of the specimens of **marble** exhibited in the Central Museum, Madras, with notes on the localities in which they are found, was compiled by Dr. Balfour in 1854 (**69**—1).

Arcot (N.).—The rocks of the **gneissic series** offer an inexhaustible supply of building stone, much of it of great beauty and value. **Quartzites** may be obtained from the Cuddapah series, but are too hard and expensive in working to be used except for rough masonry; while the **sandstones** of the Rajmahal beds are not hard enough, except in a very few cases, to be of much value (Foote, **596**—20, 207).

Arcot (S.).—Leschenault de la Tour (**1062**—1, 333) notes the occurrence of a **jade-like rock**, suitable for ornamental purposes, about 2½ miles to the W. of TIRNAVALOUR (TIRUVANANALUR, 11° 51′ 30″ : 79° 25′ 30″). The stone is very hard and compact, of an apple green colour, and takes a very high polish.

The **sandstones** of the Cuddalore group are quarried to a small extent at VELUR (11° 48′ : 79° 22′) and at VELLUMPALAIYAM, on the Gadilam R. (Blanford, **147**—8, 205). The stone is compact, moderately fine in grain, and easily quarried. It appears to be well adapted for building.

Bellary.—An account of the building and ornamental stones found in the district has been given by Foote (**596**—39, 199-205). An appendix (p. 213) also contains a complete list of quarries and localities where granite of good quality can be raised. The following localities and varieties of stone are especially mentioned :—

DAMMUR (15° 18′ : 76° 59′). **Granite** of a rich deep red colour, of medium to rather coarse grain; a superb decorative stone if well polished.

TORANAGAL HILL (15° 12′ : 76° 44′) } Dark blackish
KURIKUPPA HILL (KOREEKOOMPA, 15° 13′ : 76° 43′) } grey **porphyry**, with bright flesh-coloured crystals of felspar of large size.

KAPGAL HILL (15° 12′ : 77° 2′ 30″). Grey **granite.**

HURLIHAL (14° 43′ : 76° 37′). Dyke **porphyry**. A blackish green rock with rich green crystals of felspar. The dyke is over two

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miles long, and of considerable width. Similar prophyry occurs at KALLAKURTI (14° 47′ : 77° 9′).

TIMAPPAGARH (TIMANGARH, 15° 8′ : 76° 37′) in the Sandur hills. Riband **jasper** varying in colour from bright scarlet to delicate pinkish white or deep red and purple, highly suitable for inlaid work. Similar rocks also occur at UBBALAGANDI (15° 3′ : 76° 43′), and on the path leading up to the Donimali plateau from ETTINAHALLI (YETTUNHALLY, 15° 8′ : 76° 40′ 30″).

NEMKAL (15° 1′ : 77° 0′)
METRA (15° 19′ : 76° 41′) } Green **quartzite.**

NILGUNDA HILL (14° 44′: 75° 58′)
ANGUR (14° 57′ 30″ : 75° 49′)
HARAPPANAHALLI (14° 47′ 30″ : 76° 2′ 30″) } **Potstone.** This has been used in the construction of several temples in the neighbourhood of the quarries.

HUVINA HADAGALLI (15° 1′ : 75° 59′ 30″)
TALLUR (15° 10′ : 76° 40′ 30″) } Grey or white crystalline **limestone.** Occurs in the Dharwar series, but only in small quantity.

Chingleput.—The following localities where building stone is quarried are mentioned by Foote (**596**—8, 131):—

PALAVERAM (12° 58′ : 80 13′)
CUDDAPARY Choultry (12° 56′ : 80° 11′)
PUTTANDALUM (12° 58′ : 80° 9′)
WALLAJABAD (12° 47′ : 79° 53′) } **Hornblendic gneiss.** The rock is also quarried for the manufacture of articles of domestic use, such as curry stones and rollers, mortars, etc.

NUNDIVERAM (12° 50′ 30″ : 80° 8′)
SEVEN PAGODAS (12° 37′ : 80° 15′)
TIRUKARIKUNUM (12° 36′ 30″ : 80° 7′) } **Granitoid gneiss.** A very handsome and durable, pale yellowish or pinkish white stone.

Laterite occurs at a large number of localities, and is much used for building.

Sandstones are procurable from the Rajmahal beds near CONJEVERAM (12° 50′ : 79° 46′), SIRGULPILLI(?), and SATTAVEDU (13° 26′ : 80° 1′). The stone is compact, easily dressed, and moderately durable.

Coimbatore.—Several writers (Blanford, **147**—2; —3, 246; Nicholson, **1302**, 22; Griesbach, **708**—28, 152) have called attention to the existence, near MADUKARAI (10° 54′ : 77° 0′), 7 miles S. of Coimbatore, of a band of crystalline **limestone** which would form a valuable **marble**, but has hitherto been little used. The rock is of a greyish white or flesh-pink colour. The length of the outcrop is about 7 miles, and the width varies from 100 yards to a quarter of a mile.

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Cuddapah.—The principal building material of the district is derived from the **Nerji limestone** formation, which covers a wide area. The stone is very compact, sub-crystalline, and extremely fine grained, with a wide range of colours, from bluish grey to black. Some varieties are capable of a high polish. The stone has been quarried on a large scale at NERJI (14° 39′ : 78° 35′), and some of it has been used in building the Madras University (King, **987**—7, 70, 281 ; Gribble, **707**—1, 27).

Thin **slates** are obtainable from some of the beds of the Cuddapah series (King, **987**—7, 283).

Godavari.—Stratified **sandstones** forming low hills at PADDAGURAM (PEDDAPURAM, 17° 5′ : 82° 12′) have been quarried to a considerable extent (Benza, **110**—4, 54).

Guntur.—Handsome varieties of **granitoid gneiss** might be quarried in the KONDAVIDU HILLS (16° 16′ : 80° 20′), but little use is made of them, except for rough work (Foote, **596**—17, 106).

The limestones of the Kurnool formation found on the banks of the Kistna R. between WARAPILLI and AMARAVATI (16° 35′ : 80° 25′) are largely used for building (Voysey, **1853**—6, 402). Some of these limestones take a high polish, and would make handsome **marbles** (King, **987**—7, 282).

Considerable quantities of **sandstone** have been quarried at TANGELLAMUDI (16° 17′ : 80° 39′), CHEBROLU (16° 11′ 30″ : 80° 35′), and PAVULUR (15° 51′ : 80° 14′), for canal works. The stone obtained at the two first named localities is of rich red and purple colours (Foote, **596**—17, 107).

Kistna.—A considerable variety of excellent **marbles** is to be obtained from the Cuddapah and Kurnool formations occurring in the district (Mackenzie, **1130**, 243).

Sandstones of good quality occur at the following localities, according to King (**987**—18, 252) :—

PEDDAVEGI (16° 48′ : 81° 10′). Compact even grained stone of a brilliant red colour. Hardens considerably on exposure.

TUNDKALPUDI (16° 54′ : 81° 14′). Buff coloured granular felspathic stone of perfect durability. Similar stone is found at JANAMPET (16° 46′ 30″ : 81° 7′).

Kurnool.—The **Nerji limestones**, found throughout the Khumdair valley, are much used for building (Gopalakristnamah Chetty, **675**, 98).

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Serpentinous **limestones** of pale green and yellowish colours, occasionally darker green with convoluted laminæ, occur near KURNOOL (15° 50′ : 78° 6′) and at KADRABAD, 3½ miles to the S. E. These would give a finely clouded **marble** (King, **987**—7, 166).

Madura.—The following building stones are mentioned by Foote. (**596**—24, 98-103) :—

TIRUPARAI-KUNDRAM (9° 53′ : 78° 8′) } A very handsome reddish
AMBALATHANDI (9° 55′ : 78° 6′) } **granitoid gneiss,** with pink and grey bandings. Is susceptible of being carved with great delicacy.

ARUPUKOTAI (9° 31′ : 78° 9′). Rich red **granitoid gneiss.** Masses of 18 to 20 ft. in length have been quarried. When polished, the stone resembles the finest Peterhead granite.

MUNURUPUR (9° 35′ : 78° 12′). A similar rock, but of a duller red colour.

SHAYALAPATTI (9° 36′ : 78° 10′ 30″). Massive purplish grey **granitoid gneiss,** a very handsome rock.

TIRUSHULAI (9° 32′ : 78° 16′) Banded **gneiss.** A handsome rock of high quality.

KOTAIPARAI (9° 29′ : 78° 4′). Black **hornblendic gneiss,** suitable for carved work.

PULIARPATTI (10° 7′ : 78° 44′). Banded **gneiss,** procurable in very large blocks.

KALLIGUDI (9° 41′ : 78° 2′). Pale pinkish or greyish white **granitoid gneiss,** with bands of pink garnets.

TIRUMAL (9° 43′ : 78° 7′). Fine **marble** of various colours may be procured but has not been made use of.

SIVAGANGA (9° 51′ : 78° 33′). Hard **sandstone,** probably of Cuddalore age ; it is quarried to some extent.

Malabar.—**Laterite** is commonly used for building. Only the best varieties are capable of supporting a severe crushing strain (Lake, **1025**—1, 236).

In 1845 Cullen reported (**397**—5) the discovery of a deposit of **limestone** in excavations on the breakwater at COCHIN (9° 58′ : 76° 18′). The stone is said to have furnished an excellent hydraulic **lime.**

Nellore.—Very little use is made, except as rough building stone, of the **granitoid gneiss** that might be obtained at many places in the district. A pinkish grey variety is quarried to some extent at KUCHUPUDI HILL (15° 28′ : 79° 44′), and used for making cart wheels (Foote, **596**—17, 105).

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Nilgiri.—Slabs of **gneiss** of any size required for building may be obtained in many places from exfoliating masses of this rock (Blanford, **147**—3, 244).

Pudukotai.—Very handsome **granitoid gneiss** is quarried at TIRKONUM (10° 23′ 30″ : 78° 52′), close to Pudukotai, and at KUNAMULLA (10° 35′ 30″ : 78° 52′), 14 miles to the north. Similar stone could be procured from VIRALLIMALAI (10° 36′ : 78° 36′) if required. A less handsome, but useful variety, is quarried at TRIMIEM (10° 15′ : 78° 49′).

Compact, richly ferruginous **laterite conglomerate** is largely used for rough building purposes. The most reliable and homogeneous varieties are obtained in the SHENKARAI (10° 16′ : 78° 53′) and SHAHKOTAI (10° 6′ : 78° 55′) tracts, where blocks measuring 8 × 1½ × 1 ft. are raised (Foote, **596**—18, 157 ; —24, 99).

Ramnad.—Fine crystalline **limestones** of various colours occur at PANTALAGUDI (9° 24′ : 78° 9′), but no use appears to have been made of them, except as rough stone.

The great temple at Rameswaram is built of calcareous **sandstone**, which forms a fringe along the south coast of the district. At VALIMUKKAM (9° 10′ : 78° 42′) a coarse gritty variety of the rock has been quarried on an extensive scale (Foote, **596**—24, 101).

Salem.—Le Fanu (**1048**, Vol. I, 102) notes the existence of a bed of crystalline **limestone**, admirably fitted for building purposes, at SHATTAMBUR, 7 miles N. W. of NAMAKAL (11° 13′ : 78° 13′ 30″). The outcrop extends for at least 2 miles to the E. of the village. A smaller outcrop of similar rock occurs at MAHANPOLLIAM, E. of SANKARIDRUG (11° 28′ : 77° 56′).

Tinnevelly.—Pale coloured highly siliceous **gneiss** is quarried at WADDUKARAI (9° 18′ : 77° 59′).

Fine crystalline **limestones** of various colours occur at SHENKOTAI (9° 17′ : 78° 9′), but hitherto no use has been made of them, except for rough purposes.

The gritty calcareous **sandstones** of sub-recent origin which occur in the neighbourhood of the coast have been quarried at VEDANATTAM (8° 58′ : 78° 12′), and used for building at Tuticorin. Similar beds occurring at PANAMPARAI (8° 28′ : 78° 0′), KUDUNGKULAM (8° 11′ 30″ : 77° 45′), and THISSIANVILLAI (TEGGAYANVELLA, 8° 20′ : 77° 55′) also yield fine building stone, which has been used in the construction of ancient temples at Tiruchendur, and of

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modern churches at Megnanapuram, Mudalur, and Iddayangudi (Foote, **596**—24, 101).

Travancore.—The supply of building stone of excellent quality is practically unlimited, but little use appears to have been made of it, except for the construction of fortifications.

Some of the hard **sandstones** from the Warkalli beds have been used to a limited extent for building (Foote, **596**—25, 35).

Trichinopoly.—**Basalt** is largely used for building purposes in the valley of the VELLAR R., which forms the northern boundary of the district (Muzzy, **1278**, 91).

Blanford (**147**—8, 202) has given a description of the native method of quarrying **gneiss** and of the tools employed, also of the method of burning **lime** (p. 207), for which *kankar* and shells alone are used.

A band of **calcareous grit** occurring at the base of the Utatur group, and forming a ridge between the villages of VAYALAPADDI (11° 20′ 30″ : 79° 11′) and VARAKPADI (11° 10′ : 78° 58′) is quarried to a considerable extent. The stone is compact, but does not bear exposure to the weather (Blanford, **147**—8, 205).

King (**987**—1) has described a band of crystalline **limestone** occurring at NAIVAILI (10° 58′ : 78° 36′ 30″). The band is from 6 to 7 ft. thick and has been traced for more than 2 miles. The colour of the stone is grey, white or pink. A similar band occurs at MUTUM, 4 miles to the north. In both cases the rock is well adapted for building purposes.

Vizagapatam.—Red and white dolomitic **limestone**, occurring near KONDAJORI (18° 57′ : 82° 19′) in the Jeypore Zamindari, would make a very pretty ornamental stone when polished.

Potstone is quarried to a small extent for building and other purposes near ONTAGAON (18° 52′ : 82° 35′) to the W. of Jeypore (Walker, **1872**—2, 175).

MYSORE.

Kankar is widely distributed throughout the State, and is extensively used for the manufacture of **lime**, some six or seven thousand tons being transported annually by rail for this purpose (Primrose, **1431**—8, 227). A statement of the number of kilns and output of lime in the Chitaldroog and Shimoga districts is quoted by Sambasiva Iyer (**1548**—7, 249).

Sankey (**1555**—2) gives the results of analyses of samples of **limestone** from various localities in Mysore, and Nicholson (**1301**—3)

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has described the results of experiments in the manufacture of **cements**, carried out at Bangalore.

Chitaldroog.—A pink variety of **granite** found in the Chitaldroog Taluk is used for building (Sambasiva Iyer, **1548**—5, 116).

Wetherell (**1915**—9, 34) states that a vast amount of dark grey crystalline **limestone** occurs to the E. of JAVANGONDANHALLI (13° 50′ : 76° 49′).

Fissile slaty **schists** are largely used for building in the Chitaldroog Taluk (Sambasiva Iyer, **1548**—5, 116). A chloritic variety of schist is quarried at JUGALUR (14° 31′ 30″ : 76° 24′), and is used for flooring. Slabs of any size required may be obtained (Sampat Iyengar, **1549**—1, 92).

Hassan.—Foote in 1900 (**596**—45) called special attention to the existence of green (fuchsite) **quartzites**, highly suitable for ornamental work, in the neighbourhood of BELVADI (13° 17′ : 76° 3′). A later account by Sambasiva Iyer (**1548**—11, 35) gives further particulars of the distribution of these quartzites. They are said to be exposed also near SINDAGERE (13° 19′ : 76° 2′), in the Kadur district, a short distance to the N. W. of Belvadi.

Mysore.—Balaji Rao (**68**—5, 153) notes the occurrence of two bands of grey crystalline **limestone** close to the site of the Cauvery dam. The quantity available appears to be large.

The existence of a dyke of reddish brown felspathic **porphyry** on KARIGATTA HILL (12° 25′ 30″ : 76° 46′), near Seringapatam, was noted in 1888 by Foote (**596**—34, 56), who says that it would yield an inexhaustible supply of superb decorative stone. He afterwards compiled a list of similar dykes occurring in the Seringapatam and adjoining Taluks (**596**—46). These dykes have since been examined in detail by Sampat Iyengar (**1549**—2), who gives a complete list showing their distribution and dimensions in an appendix to his report (pp. 54-60), and by Balaji Rao (**68**—4). Dykes measuring from 2 to 4 miles in length occur at TADGAVADI (12° 26′ 30″ : 76° 53′), SIDLINGAPUR (12° 22′ : 76° 42′), NARANKERE (12° 27′ : 76° 56′), and TURGANUR (12° 23′ : 76° 57′ 30″). The width in some cases is said to be more than 10 yards.

Tumkur.—A dyke of **amphibolite**, occurring to the E. of KADEHALLI (? 13° 7′ : 76° 52′ 30″), has been quarried and used extensively in the building of the palace at Mysore. Other exposures of a similar rock were found among the hills N. E. of

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CHENNARAYAPATNA (12° 54′ : 76° 27′) in the Hassan district (Sampat Iyengar, **1549**—3, 42).

Massive **limestone** occurs half a mile to the S. W. of VOBLAPUR (13° 26′ : 77° 13′). The outcrop is of small extent, but it furnishes a fine quality of lime (Primrose, **1431**—8, 227).

Massive dark grey **limestone** similar to that found near Javangondanhalli in the Chitaldroog district is also exposed, according to Wetherell (**1915**—9, 34), to the S. E. of NERLAGUDDI (13° 44′ : 76° 48′).

NORTH-WEST FRONTIER PROVINCE.

Hazara.—The following building materials are mentioned by Middlemiss (**1219**—17, 286):—

The **gneissose granite** largely developed in the northern and western portions of the district splits readily into slabs, but is used only locally for building.

Triassic **limestone** is quarried near ABBOTABAD (34° 9′ : 73° 16′) and HASSAN ABDUL (33° 50′ : 72° 45′), and furnishes a good durable stone, but somewhat sombre in colour.

Limestone suitable for the making of **lime** is widely distributed, especially in the Slate and Nummulitic zones.

The harder courses among the Murree **sandstones**, found in the southern parts of the district, furnish an easily worked and fairly durable material.

Some of the finely foliated **schists** are used for roofing purposes. Slabs of large size can be obtained, but are from ½ to 1 inch in thickness.

Waagen and Wynne (**1860**, 334) suggest that the Attock **slates** might afford valuable roofing material.

Kohat.—The nummulitic **limestones** would supply a considerable variety of building material of excellent quality; as well as the harder bands of slightly calcareous **sandstone** occurring in the lower Tertiary group. **Flagstones** could probably be obtained from among the more thinly stratified layers (Wynne, **1975**—15, 294).

PUNJAB.

Gurgaon.—In 1867 Campbell (**270**) drew attention to the existence of **slates** of good quality in the neighbourhood of REWARI (28° 12′ : 76° 41′), especially at the base of the KHOLI HILLS, 3 miles W. of the town. These slates are now being quarried by the Kangra Valley Slate Co. The average annual output for the five years 1909 to 1913 was 2,465 tons.

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Jhelum (Salt Range).—Banded and concretionary nummulitic **limestone,** found on the Salt Range plateau above the head of the SARDI GLEN (32° 41 : 72° 47′) have been quarried for ornamental purposes (Wynne, **1975**—18, 299). Both flesh-coloured and black marbles might be obtained from the carboniferous limestones, blocks of which are procurable in any size required, and take a high polish (Fleming, **591**—5, 264). VARCHA (WURCHA, 32° 25′ : 72° 2′) and the NARSING WAHAN near KATHA (32° 31′ : 72° 29′) are mentioned as convenient sites for quarries.

A band of pisolitic **ironstone,** occurring at the base of the nummulitic series, has also been quarried for ornamental purposes (Wynne, **1975**—18, 299).

The **Purple sandstones** at the base of the Cambrian group have been largely used as building stone (Wynne, **1975**—18, 298); but Fleming in 1853 pointed out (**591**—5, 255) the superior quality of the overlying **Magnesian sandstone** for this purpose. This stone is now being quarried on an extensive scale at JUTANA (32° 43′ : 73° 13′) and other places in the neighbourhood for the Jhelum Canal Works.

Calcareous **tufa,** occurring in many parts of the Salt Range, has been used in preference to all other materials by the ancient temple builders. Though light and porous, it appears to have withstood the action of the weather very well (Wynne, **1975**—18, 298).

Kangra.—The existence of **slates** of good quality along the southern flanks of the DHAULADHAR RANGE, between Kangra and Chamba, appears to have been first noticed by Cunningham (**399**—5, 229), who mentions that many of the hill villages and towns are roofed with them. Medlicott (**1197**—5, 176) describes these slates as consisting of a purely siliceous rock, extremely fissile, and easily dressed. Large quantities are now being raised annually by the Kangra Valley Slate Co. at KANHIARA (32° 12′ : 76° 24′), near Dharmsala, and at other places by the Bhargava Slate Co. For the five years 1909 to 1913 the average annual output was 5,155 tons.

Patiala.—Bose (**173**—21, 59) has given an account of the building materials available in the Narnaul division of the State :—

Black **limestone,** well suited for the manufacture of **lime** is found at DHANI BATHANTA (27° 59′ : 76° 10′), 4 miles S. E. of Narnaul, and at BALIARI (27° 51′ : 76° 12′ 30″).

Black and white **marbles** are worked at the MANDI and DATLA HILLS (28° 3′ : 76° 8′), near Narnaul, and a band of white marble,

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200 ft. thick, is quarried at BIHARIPUR (27° 55′ : 76° 8′). Similar marble occurs at DHONKORA (27° 51′ : 76° 6′), but has only been worked to a small extent. Black or black and white banded marbles also occur at MAKANDAPUR (27° 59′ : 76° 8′); JALANWALI near ISLAMPUR (27° 55′ : 76° 6′), where they have been rather extensively worked; and at GOELA, on the southern edge of the district.

Schistose **quartzites** have been extensively quarried in the hills W. of BEGOPUR (27° 56′ 30″ : 76° 7′). The rock is micaceous and splits easily along the planes of lamination.

Quartzitic **sandstones** are worked at BALIANA and RAJAWAS (28° 18′ : 76° 7′), and between MANDLANA (28° 6′ : 76° 9′) and KHASPUR (28° 7′ : 76° 12′).

Simla.—**Limestone** is quarried at PROSPECT HILL, near Simla, and has been used in building the Simla town hall; but specimens submitted to the Geological Survey for examination were found to be very friable and impure. The Sanjauli **quartzites** form an excellent building stone (Hayden, **793**—28, 16).

Massive beds of **sandstone** suitable for building occur in abundance among the lower groups of the sub-Himalayan series. The Siwalik sandstones are usually too soft and friable for the purpose (Medlicott, **1197**—5, 175).

Hutton (**900**—2, 909) notes the occurrence of **slates** of good quality at SHARMALI, six days' journey to the north of Simla.

RAJPUTANA.

Ajmer-Merwara.—**Limestone** is quarried at KHETA KHERA, 6 miles to the N. E. of BEAWAR (26° 6′ : 74° 23′).

The Alwar **quartzites** furnish an abundant supply of good building stone. The best quarries are situated at SILLORA (26° 32′ : 74° 54′ 30″) in the Kishangarh State, and at SRINAGAR (26° 26′ : 74° 50′). Slabs measuring from 14 to 20 ft. in length may be obtained (La Touche, **1033**, 7).

Alwar.—White **marble** of good quality occurs near DHADAKIR (27° 36′ : 76° 37′), but lies at a considerable distance from the railway (Hayden, **793**—31, 16; **B.** 463).

According to Hacket (**730**—2, 92;—4, 250), white **marble** also occurs at JHERI (27° 14′ : 76° 16′), and coloured marbles at KHO (27° 11′ : 76° 26′) and BALDEOGARH (27° 7′ 30″ : 76° 26′ 30″). Black marble can be procured from the MOTIDONGRI RIDGE, near Alwar.

Quartzite of an excellent quality is largely quarried at BERLA (27° 23′ : 76° 50′) and other places in the neighbourhood. It is

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pearl grey in colour, very durable, and easily worked. Quarries might be opened in any part of the four ridges to the E. of MALAKHERI (27° 23′ : 76° 41′ 30″).

Schistose **quartzites** used for roofing flags, etc., are quarried near RAJGARH (27° 14′ : 76° 41′) and MANDAN (28° 6′ 30″ : 76° 26′).

The Ajabgarh **slates** have been used for roofing the stations on the railway. A band of excellent slate is now being worked by the Kangra Valley Slate Co. near KUND station on the Rewari-Phulera railway (Hayden, **793**—26, 85).

Bharatpur.—The celebrated **sandstone** quarries situated between BHARATPUR (27° 13′ : 77° 33′) and RUPBAS (27° 0′ : 77° 39′) have been fully described by Hardie (**764**—6, 329), Robinson (**1500**), and Mallet (**1159**—3, 118). The beds worked are those of the upper Bhander group, the highest member of the Vindhyan series. According to Mallet, two marked varieties of stone are quarried; one of dark red colour, speckled or streaked with yellowish white spots or blotches; the other yellowish white, and of a very fine and homogeneous texture. Of these, the red variety is of distinctly inferior quality, as compared with the white, but it sometimes possesses a perfectly parallel lamination, which enables it to be split into flags of various thicknesses, extremely useful for roofs or flooring.

Tests of the relative strength of the sandstones, carried out by Boileau (**167**), showed that while the white variety lost nearly half its strength when saturated with moisture, that of the red variety was only slightly affected; and that the latter was therefore the more suitable for roofing purposes. In a dry state, the strength of the white variety, as compared with that of the red, was in the proportion of 17 to 11 (**B.** 545).

Bikaner.—Red **sandstones** of upper Vindhyan age have long been quarried on an extensive scale at DULMERA (28° 25′ : 73° 43′), 30 miles to the N. E. of Bikaner. The stone is a fine grained freestone of first rate quality. Practically the whole of the town of Bikaner is built of sandstone from this neighbourhood (Powlett, **1423**—1, 97).

Jaipur.—White **marble** occurs in large quantities, but is rarely free from crystals of tremolite, which spoil its appearance (Hayden, **793**—31, 16). The best quality was found at MAUNDLA (?). Hacket (**730**—2, 92) mentions quarries of white marble at RAIALO (27° 5′ : 76° 17′). Finely laminated argillaceous **flags** are procured at SALIMPUR (27° 6′ : 77° 2′).

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Schistose **quartzites,** used for roofing, etc., are quarried to the N. of AMBER (26° 59′ : 75° 55′).

Sandstone is quarried at RAGHUNATHGARH (27° 40′ : 75° 24′). The rock is a white, fine grained freestone, and is obtained in large thick slabs, which are despatched often to great distances (Hayden, **793**—31, 17).

Jaisalmer.—The town of JAISALMER is built of **limestone** of Jurassic age, which is quarried on an extensive scale in the neighbourhood (Blanford, **148**—50, 15). It is of uniform texture and very fine grain, is capable of being finely carved, and resists the action of the weather well. Slabs of this material have been taken to distant places for temples, tombstones, etc.; some of those in Sind having elaborate Arabic inscriptions cut upon them.

The village of ABUR (27° 5′ : 70° 37′) is situated upon a band of fossiliferous **limestone** of a dark red colour, in which the fossils have been converted into a yellow substance, forming a very handsome **marble.** It is known throughout northern India as "**Abur stone,**" and possesses a semi-sacred character, blocks of it being placed as thresholds in many of the temples (Oldham, **1324**—18, 159).

Marwar (Jodhpur).—The celebrated quarries of white **marble** situated at MAKRANA (27° 2′ : 74° 47′), which are said to have furnished the stone for the building of the Taj Mahal at Agra, have been worked for ages, but have never been adequately described. The marble forms a series of ridges barely elevated above the surrounding sand hills, corresponding in direction with the strike of the rocks from N. N. E. to S. S. W., and extending for a considerable distance to the S. W. of the village. The quarries are deep trenches, in which the marble occurs in bands with a high easterly dip, some of which are upwards of 2 ft. in thickness (Hacket, **730**—4, 250), separated by layers of micaceous schist, and occasionally traversed by veins of coarse granite. Some of the bands are of a grey colour, but many are of the purest white. The quantity of the best marble still available is said to be very large (Hayden, **793**—31, 17). It is being employed in the building of the Victoria Memorial in Calcutta, but much of it is still worked up on the spot into those beautiful pierced screens which are so conspicuous a feature of the native architecture of northern India.

A large mass of white **marble** occurs at SARANGWA (25° 17′ : 73° 34′) in Godwar, and has been quarried to a considerable extent (La Touche, **1034**—28, 17). The rock is of a somewhat coarser texture than the Makrana marble, but of a pure white colour.

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The hills in the neighbourhood of JODHPUR city are capped with alternating beds of fine and coarse grained **sandstone**, of upper Vindhyan age, from which inexhaustible supplies of the most excellent building stone may be obtained. The finer beds afford material not only for the walls of the houses, but also for beams to support the ceilings, as well as flags for roofing and flooring. The stone is of a soft reddish tint, is easily worked and thoroughly durable, and is susceptible of the most delicate carving. Splendid examples of its architectural capabilities, in conjunction with white marble, may be seen in the old palace and fort at Jodhpur (La Touche, **1034**—28, 28).

Mewar (Udaipur).—Hardie (**764**—7, 78; —8, 62) mentions the existence of large quarries in white and grey crystalline **dolomite** at KANKROLI (25° 3′ 30″ : 73° 57′). A quarry had also recently been opened in a band of fine white **marble** near the fort of MANDALGARH (25° 13′ : 75° 10′).

UNITED PROVINCES.

Middleton (**1221**—2) remarks on the characters and durability of the building stone (Vindhyan sandstone) quarried in the districts of Agra, Allahabad, Banda, Bharatpur, and Mirzapur, and gives particulars of the absorbent power of the specimens. He also gives a description of the means employed by the quarrymen for transporting large blocks of stone (**B.** 544).

Sills (**1634**) gives the results of crushing tests applied to specimens of sandstone from various quarries in the United Provinces.

Agra.—The upper Vindhyan **sandstones** are quarried in many places in the district. Reid (**1472**) enumerates 69 quarries (including those situated in the adjoining State of Bharatpur in Rajputana), and gives particulars of the method of working them. The quarries at FATEHPUR SIKRI (27° 5′ : 77° 43′) are said to have supplied the stone used for building in Agra (Voysey, **1853**—4); but, according to Reid, the stone from this locality is of inferior quality. The best stone is produced in Pargana Sarhindi, where it is of a grey and red colour, and of a texture suitable for all kinds of architectural work.

The arts of inlaying, screen piercing, and soapstone carving, practised at Agra, have been described by Keene (**968**).

Allahabad.—Quarries in the upper Vindhyan **sandstones** at PARTABPUR (25° 17′ : 81° 37′) were opened by Government in 1863

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(Owen, **1354**). The stone worked is a fine grained homogeneous sandstone of a light reddish colour, occurring in beds 6 to 8 ft. thick. The stone is brought to Allahabad by water, and was used for building the railway bridge over the Jumna. A full description of the native quarries at this locality was given in 1846 by Monckton (**1239**). Sandstone of a similar kind is also quarried at SEORAJPUR (25° 12′ : 81° 40′), on the East Indian railway (Mallet, **1159**—3, 117).

Almora (Kumaon).—Good building stone is to be obtained almost everywhere in the district (Lawder, **1040**—1, 89). Fine grained evenly bedded **quartzites** are used for the purpose at ALMORA itself (29° 36′ : 79° 43′), and a pale coloured **gneiss** at RANIKHET (29° 38′ : 79° 29′). Herbert (**827**—6, 234) mentions the occurrence, close to Almora, of a porphyritic grey **granite**, which would be suitable for ornamental work.

Limestone is found in great abundance in the district, but lime is usually manufactured from beds of calcareous tufa (Lawder, **1040**—1, 89).

A special report on the **slates** of CHITELI (29° 49′ : 79° 28′ 30″), in connection with their use for roofing purposes at Ranikhet, was drawn up by Hughes (**888**—5) in 1870. They were pronounced to be inferior to Welsh slates, being laminated (not cleaved), and more siliceous and coarser in texture; but slabs of less than ¼ in. in thickness, and of sufficient size, could readily be obtained from the lower bands exposed in the quarries.

Herbert (**827**—10, cxvi) states that perfect roofing slates occur in abundance at LOHUGHAT (29° 24′ : 80° 9′).

Dehra Dun.—Blane (**145**, 61) mentions the existence of **slate** quarries in Jaunsar, but does not say where they are situated. The slates are used for roofing houses in many of the hill villages.

Jalaun.—A peculiar use to which *kankar* is put in this district has been described by Smith (**1656**—1, 624). The *kankar* is found in the form of thin plates at the base of the high banks of older alluvium on the Jumna R. near the village of KARIM KHAN, opposite BHADAURA (26° 23′ 30″ : 79° 34′), and in the bed of the river. Slabs measuring from 2 to 4 ft. in length by 1 to 2 ft. in breadth can be procured, and are used to form the projecting eaves of roofs, and as dripstones over the windows at Kalpi and other towns and villages in the neighbourhood. The peculiar formation extends for about half a mile along the river.

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Mirzapur.—Mallet (**1159**—5, 19) has described a fine verde-antique **marble** occurring near the mouth of the BICHI STREAM (24° 8′ : 83° 0′), a tributary of the Rer R. The rock is a white crystalline dolomite, interbanded with rich green serpentine and layers of tremolitic hornblende. Slabs measuring from 3 to 6 feet across, transverse to the bedding and showing the alternation of limestone and serpentine, might be procured in any quantity.

The Kaimur **sandstones,** or lower group of the upper Vindhyan series, have been quarried on a very extensive scale at MIRZAPUR (25° 9′ : 82° 37′), CHUNAR (25° 8′ : 82° 57′), and intermediate points for many centuries, and the stone is well known for its excellent qualities throughout the lower Ganges valley. The rock is fine-grained and compact, of reddish yellow or greyish white colour, and is very durable. The beds often spread for long distances without joints or fissures, so that very large blocks can be obtained (Mallet, **1159**—3, 116; **B.** 540, 544).

Reports on the working of the quarries were drawn up by an anonymous writer in 1841 (**35**—12), and by Money (**1241**) in 1846. At that time there were 283 quarries open, and 894 closed; but few of them were worked to a depth of over 25 ft.

The average annual production of stone at Chunar, during the five years 1909 to 1913, was 163,864 tons.

Tehri-Garhwal.—Excellent roofing **slates** are said to be found along the valley of the AGLAR R. (30° 30′ : 78° 6′), to the N. of Mussoorie (Herbert, **827**—10, lxxxix).

CARNELIAN, *see* **GEM-STONES—AGATE.**

CELESTITE, *see* **RARE MINERALS—STRONTIUM.**

CEMENT, *see under* **BUILDING MATERIALS.**

CERIUM, *see under* **RARE MINERALS.**

CHROMITE.

ANDAMAN ISLANDS.

Mallet (**1159**—38, 204;—42, 83) records the discovery of blocks of chromite at the village of CHAKARGAON (11° 39′ : 92° 42′), near Port Blair. The mineral was not found *in situ*, but was supposed to have been associated with serpentine, which is known to occur in the neighbourhood. The quantity available is probably not large, for the blocks appear to be confined to one spot.

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BALUCHISTAN.

Quetta-Pishin and Zhob.—The discovery of chrome iron ore in Baluchistan dates from the year 1901, when Vredenburg reported its existence as veins and segregated masses in serpentines associated with igneous intrusions of upper Cretaceous age, distributed along the hills bordering the Zhob valley, and the upper part of that of the Pishin R. About 2 miles to the E. of KHANOZAI (30° 37′ : 67° 20′) a mass consisting of almost pure ore was found, measuring about 400 ft. in length by 5 ft. in breadth, and containing over 54 per cent. $Cr_2 O_3$ (*see* Holland, **859**—38, 9).

Active exploitation of the mineral began in 1903, when 284 tons were raised and exported. Between that year and the end of 1913, no less than 115 mining leases were applied for and granted, 12 in the Quetta-Pishin district and 103 in Zhob, 72 of the latter being issued in one year, 1909. No adequate prospecting operations appear to have preceded the applications for most of these leases, for the output has by no means kept pace with the multiplication of concessions. The maximum quantity produced was in 1907, 7,274 tons; but since that year production has considerably fallen off. The average annual production, during the five years 1909 to 1913, was 3,633 tons. In 1914 the output amounted to 3,006 tons, and in 1915 to 2,161 tons.

BIHAR AND ORISSA.

Singhbhum.—In the year 1907 a deposit of chromite was discovered by Mr. R. Saubolle at the SURA PASS (22° 33′ : 85° 43′), on the road between Chaibasa and Sonua, Bengal-Nagpur Railway. It occurs in the form of bed-like veins up to 10 ins. in width in serpentine, and as disseminated grains in the same rock. In the course of prospecting operations about 400 tons of ore were extracted. Samples of the ore yielded 50·05 per cent. $Cr_2 O_3$ (*see* Holland, **859**—71, 34).

Annual outputs of 848, 552, and 565 tons of ore from this neighbourhood have been reported during the three years 1913 to 1915.

BURMA.

Myitkyina.—Small crystals of chromite are disseminated through the serpentine of the TAWMAW jade tract (25° 42′ : 96° 17′), but not in sufficient quantity to be of commercial value (Bleeck, **154**—3, 259).

MADRAS.

Salem.—The existence of chromite in association with the magnesite of the 'Chalk Hills' near Salem appears to have been discovered

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by Mr. Heath early in the last century. In 1832 Prinsep (**1436**—11, 254) gave a description of specimens of the mineral sent to him from the mines opened by the Porto Novo Iron Co. at KARUPPUR (11° 43′: 78° 9′), and says that works had been established in Salem for the preparation of bichromate of potash. Ten years later Newbold (**1294**—29, 167) described the mode of occurrence of the ore, as seen in the shafts, which had been abandoned after the extraction of about 100 tons of chromite. It was found, he says, in irregular veins, or forming detached nodular or angular masses imbedded in the magnesite. On analysis the ore was found to contain 49 per cent. $Cr_2 O_3$. Later accounts by King and Foote (**988**, 315), Holland (**859**—5, 143), and Middlemiss (**1219**—18, 34; —20) agree substantially with that given by Newbold. According to Holland (**859**—30, 133), the chromite is associated with intrusions of ultra-basic rocks (dunites), and is considered to have been segregated into nodules and bands during the early stages of the consolidation of these rocks (**B.** 332).

The irregular manner in which the chromite occurs in the 'Chalk Hills' area renders it impossible to form an estimate of the quantity available.

Similar conditions were found by Holland to be present at the N. W. base of KANJAMALAI HILL (11° 37′: 78° 7′), and a small outcrop of chromite, forming a vein 4 ins. thick in magnesite, was found at this locality by Middlemiss (**1219**—18, 37).

MYSORE.

A list of localities in which chromite has been found is given by Slater (**1649**—5, 25).

Hassan.—Sampat Iyengar (**1549**—3, 41) states that chromite is an important member of the Nuggihalli schist band, which extends in a S. S. E. direction from ARSIKERE (13° 18′ 30″: 76° 19′). It was found largely developed at several localities between that place and NUGGIHALLI (13° 1′: 76° 32′ 30″). It is associated with an ultra-basic rock, in which it occurs in lenticular masses. The quantity available was roughly estimated at 30,000 tons. The quality of the ore varies considerably, the yield of chromic oxide ranging on analysis between 30 and 50 per cent. (Venkataramaiya, **1838**—1).

Mysore.—Clark (**321**—2, 117) mentions a discovery by Captain Haldane of a good deal of chromate of iron in the Residency compound at YELWAL (12° 21′: 76° 36′).

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In 1905 Sambasiva Iyer (**1548**—11, 41) noted the occurrence of small masses of chromite imbedded in dunite near SHINDUVALLI (12° 12′: 76° 42′). Subsequent prospecting work showed that the mineral extended over a wide area between KADAKOLA (12° 11′: 76° 43′ 30″), a station on the Mysore railway, and MAVINHALLI (12° 13′: 76° 36′). From this tract about 10,000 tons of ore had been collected and exported up to the year 1912 (Venkataramaiya, **1838**—3, 165).

Raghavendra Rao (**1450**, 142) has noted the occurrence of blocks of chromite at the edge of a belt of schists about half a mile W. of KRISHṄARAJPET (12° 40′: 76° 33′), and near KABBAL (12° 50′ 30″: 76° 32′).

The record of production of chromite in Mysore reflects the sporadic manner in which the mineral occurs. In 1907, the year after the first concession was taken up in the Kadakola area, it amounted to 11,000 tons, all of which must have been derived from shallow pits excavated in the numerous veins and lenticular masses which were then visible at the surface; or have been collected in the form of loose weathered blocks from the beds of streams. As these sources of supply quickly became exhausted, the production fell to only 610 tons in 1908. A partial recovery took place in 1909, due probably to the exploitation under similar conditions of the superficial deposits in the Nuggihalli area. The production for that year was 4,925 tons, but for the three following years the returns were blank. For the years 1913 to 1915 inclusive, outputs of 1,414, 2,330, and 1,041 tons have been recorded.

PUNJAB.

Kangra.—Mallet (**1159**—1, 166) states that fragments of chromic iron ore are scattered in some abundance through the debris on the borders of the HANLE CHU (32° 47′: 79° 4′) in Spiti. They are probably derived from serpentinous rocks, which form much of the hills on either side of the river, especially on the west, but the ore was not observed *in situ* (**B.** 334).

CLAY, *see under* **BUILDING MATERIALS, FIRE-CLAY,** *and* **KAOLIN.**

COAL.

The following reports and papers deal with the general distribution of coal in India :—

1838-46. McClelland (**1117**—15; —16; —17; —25; —31). Reports of a committee for investigating the coal and mineral resources of India.

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1846-47. Ansted (**36**—1; —2). Coal districts of India.

1863. Oldham (**1326**—33). Gives details of the working of each colliery, and statistics of output for the years 1858-60.

1863. McClelland (**1117**—36). The coal fields of India.

1868. Oldham (**1326**—48). The coal resources and production of India. Contains a table of analyses of 74 samples of coal, and statistics of output for Bengal.

1869. Oldham (**1326**—52). Statistics of output of each colliery for the years 1867-68.

1873. Hughes (**888**—11). Estimates the total area of the Indian coal fields at 35,000 square miles.

1873. Blanford (**148**—42, 388). General remarks on the distribution of coal.

1877. Hughes (**888**—21). Gives particulars of the cost of boring for coal in India, and describes the methods employed.

1879-81. Ball (**71**—39; —44, 58; —45, 59-120). General accounts of the mode of occurrence and distribution of coal.

1898. Dunstan (**514**—1). A brief account of the distribution of the coal fields, with tables of analyses.

1900. Mahon (**1153**—3). On the coking quality of Indian coals.

1902. Dunstan (**514**—4). The coal resources of India and their development. Contains tables of analyses, and statistics of output for the years 1895 to 1900.

1910. Pickering (**1402**—3). The coal deposits of India.

1911. deLaunay (**459**—2, 311).
1911. Schreiber (**1585**) } General accounts of the Gondawana coal fields, chiefly compiled from the publications of the Geological Survey of India.

1913. Ball and Simpson (**72**). A revision, entirely re-written, of the chapter on coal (Chap. II) in Part III of the Manual, Geology of India.

1913. Ashton (**45**). A history of the development of the Indian coal fields.

Tables of analyses of Indian coals are also given in the following papers :—

1831. Prinsep (**1436**—8, 280).

1838. Prinsep (**1436**—30).

1852. Piddington (**1405**—49).

1868. Danvers (**417**—1). Remarks on the quality of Indian coal, with special regard to its employment on railways and steamers.

1895. Abel (**4**—1).

1906. Dunstan (**514**—14).

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1910. Hughes (**885**—3). Gives determinations of the calorific value of a number of samples of Indian coal.

N.B.—References to Ball and Simpson's Memoir on the coal fields of India are denoted below by the letter **S.**

AFGHANISTAN.

AK ROBAT (34° 55′: 67° 42′). Thin anthracitic seams, probably of Carboniferous age, are mentioned by Griesbach (**708**—13, 241). These have since been examined by Hayden (**793**—22, 58), and shown to be graphitic schists of no value as fuel (**S.** 12).

CHAHIL VALLEY (35° 38′: 67° 37′) and SHISHA ALANG (35° 42′: 67° 26′). Numerous seams of coal occur, several of them over 6 ft. in thickness. Details of the sections exposed at these localities are given by Griesbach (**708**—13, 243, 246), who estimated the quantity available from the best seam, 6 ft. thick, over an area of 9 sq. miles in the neighbourhood of Shisha Alang, at 50 million tons (**S.** 12).

ANDAMAN ISLANDS, *see under* **LIGNITE.**

ASSAM.

Henderson (**811**) gives particulars of the discoveries of coal made in Assam up to the year 1838. A general account of the distribution of the Assam coal fields was compiled in the same year by McClelland (**1117**—12).

Beneath the fringe of Siwalik sandstones which occurs along the base of the Himalaya on the northern side of the Assam valley, a band of coal-bearing Gondwana rocks has been met with wherever the outer hills have been penetrated. In each case the coal is intensely crushed and friable, and its value as fuel is negligible. The band is known to occur at the following localities :—

Abor Hills.—SIRPO STREAM (27° 8′: 95° 15′). Lenticular patches of coal up to 4 or 5 ft. in thickness (Brown, **211**—5, 239, 252).

Aka Hills.—BORHOLI R. (27° 10′: 92° 45′). Thin seams and lenticular patches of coal. The thickest seam measures 18 ins. (La Touche, **1034**—6, 122).

Daphla Hills.—DIKRANG R. (27° 13′: 93° 45′). A seam of coaly shale 5 to 6 ft. thick (Godwin-Austen, **669**—19, 37).

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The productive coal fields of Assam occur in rocks of Cretaceous or Tertiary age :—

Garo Hills.—DARANGGIRI (25° 27′: 90° 46′). First described by Medlicott (**1197**—33). Productive area about 20 sq. miles. Average thickness of workable seam 5 ft. 6 ins. Estimated total quantity of coal available, 76 million tons, most of which lies above the main drainage level. The field is situated in the centre of the hills, and is somewhat difficult of access (La Touche, **1034**—1). Average analysis (2 samples):—C=49·8 : Vol.=36·3 : Water=8·8 : Ash=5·1 per cent. (**S.** 24).

HARIGAON (25° 34′: 90° 8′). Bedford (**96**—2) records the existence of coal seams, 2 to 3 ft. in thickness, at SALKURA and MIRAMPARA, but Medlicott (**1197**—12, 14) has shown that the so-called coal is merely a resinous shale, of no value as fuel (**S.** 23).

PUNDENGRU (25° 17′: 90° 59′). Godwin-Austen (**669**—17, 43) notes the occurrence of four seams of coal, from 3 to 8 ft. thick, below the scarp at the crest of the hill. The total thickness of coal exposed is about 20 ft.

RONGRENGGIRI (25° 33′: 90° 37′). Coal measure rocks, probably once continuous with those of the Daranggiri field, extend for about 7 miles along the valley of the Someshwari R., but no coal of practical value has yet been found among them (Medlicott, **1197**—33, 60 ; La Touche, **1034**—1, 175). A few outcrops were discovered by Datta (*see* King, **987**—48, 5) in 1891, but the best of them indicated a seam of only 15 ins. in thickness (**S.** 24).

SIJU (25° 21′: 90° 45′). A seam of highly resinous coal, 3 ft. thick, is exposed at the base of the hills immediately north of the village, and is brought up by a roll in the strata on the banks of the Someshwari R. to the south. The coal is much crushed, and too friable to bear transport to a distance (Medlicott, **1197**—12, 13 ; **S.** 24).

Khasi and Jaintia Hills.—CHERRA PUNJI (25° 17′: 91° 47′). Coal appears to have been discovered in this area by Mr. J. Stark in 1815 (**1689**). It occurs in a single seam not exceeding 9 ft. in thickness, lying from 10 to 15 ft. above a strong band of nummulitic limestone (McClelland, **1117**—9, 69 ; Oldham, **1326**—8, 140, 185). Mining on a moderate scale was carried on for several years from 1834, when Watson (**1902**—2) reported the despatch of about a ton of the coal to Calcutta for trial. In 1842 the output was about 3,900 tons, and in 1844, 4,200 tons.

A detailed examination of the field, carried out by La Touche in 1889 (**1034**—12), showed that the thickness of the seam varies

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from 3 to 9 ft. The area of the field was found to be 136 acres, and the total quantity of coal available was estimated at 1,185,000 tons. Analysis by Prinsep (**1436**—8, 283) :—C=62·0 : Vol.=37·1 : Ash =0·9 per cent. (**S.** 26).

JARAIN (25° 19′ 30″: 92° 11′ 30″). An outcrop near this place shows from 3 ft. to 3 ft. 6 ins. of coal, but containing so large a proportion of pyrites that it is practically valueless (La Touche, **1034**—3, 199).

LAIRANGAO (25° 20′: 91° 48′). The occurrence of a seam of coal about 3 ft. thick near SURARIM, at the northern edge of this field, was noticed by Cracroft (**383**—3, 252) in 1832. The field was surveyed by La Touche in 1890 (**1034**—15). The area was found to be 320 acres ; average thickness of seam, 3 ft. ; and total quantity of coal available about 1,500,000 tons. Analysis by Cracroft (**383** —3, 250) :—C=53 : Vol=45 : Ash=3 per cent. (**S.** 27).

LAKADONG (25° 11′: 92° 20′). A single seam of coal of variable thickness is exposed along the scarps bounding two small plateaus, above a band of nummulitic limestone, as at Cherra Punji (Oldham, **1326**—3 ; —8, 145). Taking 2 ft. as the average thickness of the seam, and the total area of the field as 360 acres, La Touche (**1034**—13) estimated the total quantity of coal available at 1,164,000 tons (**S.** 30).

LANGRIN, *see* UMBLAY R. *below*.

MAO-BE-LARKAR (25° 24′: 91° 49′). A small field, covering 11 acres only, but of some importance, as it supplied the head-quarters station of Shillong for many years. The coal was shown to be of Cretaceous age by Medlicott (**1197**—17, 175). Average thickness of seam, 3 ft.; and total quantity of coal available in 1890, estimated at 52,000 tons (La Touche, **1034**—15, 123 ; **S.** 26).

MAOPHLANG (25° 27′: 91° 49′). Outcrops of coal at UMSAOMAT and DEDUM HILL, to the S. W. of Maophlang, were described in 1875 by Mallet (**1159**—8). The seam at Umsaomat is only 1 ft. thick, shaly and worthless. At Dedum hill the coal is of better quality, but contains 31·6 per cent. of ash. The seam is 3 ft. thick. No estimate of the quantity available is given (**S.** 26).

MAOSANDRAM (25° 18′: 91° 39′). The field occupies the summit of three small knolls, a mile and a half N. of the village. Total area about 22 acres. Seam variable in thickness. Taking 2 ft. as the average, the total quantity of coal available would be 63,000 tons (La Touche, **1034**—15, 122). The coal is of poor quality, but has been used to a small extent for lime burning (**S.** 27).

SATUNGA (25° 22′: 92° 30′). An outcrop of coal, 1 ft. 9 ins. thick, has been recorded by La Touche (**1034**—3, 201). Coal 1 ft. thick was also seen at NOKHARA, in the same neighbourhood (**S.** 30).

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THAN-JI-NATH (25° 18′: 91° 57′ 30″). A section of the Tertiary beds at this locality, given by Oldham (**1326**—8, 130), shows a seam of coal from 3 ft. 6 ins. to 4 ft. in thickness. It is said to thin out to the westward to 1 ft. 6 ins.

UMBLAY R. (25° 20′: 91° 5′), or LANGRIN. This is the largest coal field in the Khasi Hills, covering an area of about 30 sq. miles. The earliest mention of coal in this neighbourhood is by Jones (**956**—2, 284) in 1829, when the outcrop of a seam 2 ft. thick was found near the crest of the scarp overlooking the village of Laour in Sylhet. In 1869 Godwin-Austen (**669**—13, 11) described a section in the ravine of the Um Plu, on the northern edge of the field, showing the outcrop of four seams, with an aggregate thickness of 20 ft. 4 ins. of coal. Additional outcrops were found along the edges of the field by La Touche (**1034**—2;—4), but at such wide intervals that no reliable estimate of the total quantity of coal available could be formed. The coal is of very fair quality, analyses of samples from two of the seams exposed in a ravine near BORSORA (25° 12′: 91° 14′) giving about 50 per cent. of carbon and from 6 to 8 per cent. of ash (**S.** 28).

UM RILENG (25° 36′: 91° 52′). The outcrop of a seam of coal was discovered by Bose in 1902 at the foot of Dinghie hill, near the head waters of the Um Rileng (**173**—19). Subsequent exploration by means of borings and trenches proved the existence of a seam 5 ft. thick over an area of nearly 100 acres, equivalent to 470,000 tons of coal. The coal is somewhat deficient in fixed carbon, containing about 30 per cent., but it contains only 6 per cent. of ash (**S.** 29).

WAPUNG (25° 25′: 92° 22′) and DONGCHALA (25° 20′: 92° 23′) Griesbach (**708**—34, 18) records the discovery by Bose of outcrops of coal, about 5 ft. in thickness, at these localities. They probably occur in the same spread of Cretaceous rocks as the coal of Jarain and Satunga (**S.** 29).

Lakhimpur.—JAIPUR (27° 16′: 95° 27′). The discovery of several seams of workable coal on the banks of the Buri Dihing R. near Jaipur, and of a seam 8 ft. thick at BORHAT (27° 10′: 95° 25′) on the Disang R., was announced by Jenkins (**941**—2) in 1838. For several years the coal was worked by means of open quarries for the supply of tea gardens in the neighbourhood (Hannay, **760**—3; Medlicott, **1197**—9, 395); and in 1876 the known outcrops were examined in detail by Mallet (**1159**—9, 314), who estimated the quantity of coal available within a depth of 450 ft., over a length of outcrop of 15 miles, at 20 million tons.

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A more recent examination of the field by Simpson (**1640**—8) has shown that the outcrops extend for a length of at least 25 miles. No estimate of the amount of coal available was made, except as regards a limited area near the Disang R., within easy reach of the Assam-Bengal railway at Dilli. Ten seams were found, of which six are of workable thickness. On a moderate estimate the quantity available in this area, within 500 ft. from the surface, would be about 2,676,000 tons.

Owing to the position of the outcrops at the base of the hills, and the high dip of the seams, a very small proportion of the coal lies above the saturation level of the country, and a high water discharge must be anticipated in mining. The quality of the coal is good. Analysis (average of 8 samples):—C=55·0: Vol.=34·7: Water=5·9: Ash=4·4 per cent. (**S.** 18).

MAKUM (27° 18′: 95° 41′). No record appears to have been preserved of the discovery of this field, which is now the most productive in Assam. When visited by Medlicott in 1865 (**1197**—9, 395), a seam of hard bright coal, 5 ft. thick, was being quarried on the Tirap R. The outcrops were examined in 1876 by Mallet (**1159**—9, 304), who traced them for a distance of about 13 miles. The most valuable seams were found to lie between the Tirap and Namdang streams, a length of 5½ miles, with an average aggregate thickness of at least 30 ft. The total quantity available within a depth of 400 ft. from the surface was estimated at 18 million tons. The seams usually dip at a high angle, but since the outcrop lies at a considerable elevation above the natural drainage level, the coal is easily worked by means of adits.

Regular mining operations were begun in 1881, when collieries were opened at LEDO, TIKAK, and NAMDANG. In 1884 the output was 16,493 tons, and since then it has steadily increased to more than 300,000 tons annually. Full accounts of the system adopted in working the collieries, conditions of labour, etc., have been given by Turner (**1814**) and Harris (**768**—1). Measurements of the seams made by Simpson (**1640**—9) in 1906 show that their thickness was underestimated by Mallet. It varies from 60 ft. (50 ft. coal, 10 ft. fire-clay) at the Lower Ledo mine, to 106 ft. 6 ins. (79 ft. 6 ins. coal, 27 ft. fire-clay) at Namdang. A revised estimate of the total quantity of coal available between these places, and lying above the natural drainage of the streams, makes it about 90 million tons.

The quality of the coal is excellent. Analyses of 10 samples by Smith (**1665**) gave the following average result:—C=57·47: Vol. =40·38: Ash=2·15 per cent. It cokes well, and yielded 10,900 cub. ft. of gas per ton. Its chief defect is the high proportion of

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sulphur which it contains, and its brittle character when exposed to the atmosphere (**S.** 17).

The output in 1914 amounted to 303,890 tons, and in 1915 to 308,071 tons.

NAMCHIK or NAMRUP R. (27° 25′: 96° 2′). Three seams of coal, 3 ft., 9 ft., and 3 ft. thick respectively, were discovered in 1837 by Griffith (**709**—4, 117) and Bigge (**125**—1) close to the junction of this river with the Buri Dihing. The seams were also described by Medlicott (**1197**—9, 399) in 1865. More recently (1911) the section has been examined by Pascoe (**1369**—10), who describes it as consisting of five groups of seams within about 360 ft. of strata. The total thickness of coal exposed amounts to 60 ft., of which 5 or 6 ft. is of poor quality. Analysis (average of 2 samples) :—C=52·9 : Vol.=44·4 : Ash=2·7 per cent. (**S.** 16).

Sibsagar.—DISAI R. (26° 37′: 94° 28′). Extent of field unknown. Five or six seams, from 6 ins. to 4 ft. thick, were observed by Mallet (**1159**—9, 344) in a small lateral stream near the village of JAPU, and one of 3 ft. in the bank of the Disai. The coal is soft and crushed. Analysis :—C=54·9 : Vol.=36·9 : Water=3·4 : Ash=4·8 per cent. (**S.** 21).

DOIGRUNG R. (26° 21′: 93° 49′). An outcrop of poor coal, 3 ft. thick, has been described by La Touche (**1034**—5). The coal contains 48·76 per cent. of ash. The seam is probably continuous with that exposed in the Nambor R., 4 miles to the south-east (**S.** 22).

JAMUNA R. (26° 0′: 93° 25′). The discovery of a seam of coal, 2 ft. 6 ins. thick, near the falls on the Jamuna R., was reported by Jenkins (**938**—2) in 1835. Analysis :—C=29·9 : Vol.=60·9 : Ash =9·2 per cent. The existence of this seam has also been noticed by Brodie (*see* McClelland, **1117**—12, 949), Grange (**689**, 949), McClelland (**1117**—29), and Masters (**1190**, 58).

JANJI R. (26° 42′: 94° 42′). The length of the field is about 2 miles. Coal seams are few and unimportant, the thickest known measuring only 3 ft,, of which 1 ft. is of inferior quality (Mallet, **1159**—9, 343 ; **S.** 20).

LONGLOI HILL (25° 55′: 93° 17′). A seam of coal 12 ft. thick, probably of Cretaceous age, has been described by Smith (**1657**—2, 93). The coal is of poor quality. Analysis (average of 2 samples) : C=25·36 : Vol.=53·74 : Water=4·62 : Ash=16·28 per cent. (**S.** 21).

NAMBOR R. (26° 19′: 93° 51′). Coal was found in three places, about 8 miles above the falls on the Nambor, by Smith (**1657**—2,

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94). It is of extremely poor quality, containing from 30 to over 50 per cent. of ash (**S.** 22).

NAZIRA (26° 55′: 94° 48′). The coal measures in this field have been traced for a distance of about 16 miles across the valleys of the Saffrai, Tiru, and Dikhu rivers. A seam about 10 ft. thick, of which 4 ft. was good coal, was mentioned by Thornton (**1779**) in 1848 as occurring on the Dikhu, at a considerable elevation above the bed of the river. The outcrops were examined in 1876 by Mallet (**1159**—9, 328), who estimated the total quantity of coal available, within a depth of 350 ft. from the surface, at 20 million tons in the Saffrai area; and at 15 million tons in the Tiru-Dikhu area within 600 ft. of the outcrop. More recent investigations of the seams exposed in the lower Saffrai and Dikhu valleys by Simpson (**1640**—8, 215), and of those in the upper Saffrai and adjoining areas by Hayden (**793**—18, 295), have shown that the number of seams is very large, but that the greater proportion of the coal lies below the permanent saturation level, and at too great a distance from the railway to be readily accessible. Simpson estimated that a limited area on the Dikhu, within 7 miles of the railway, would yield about 2,210,000 tons of coal, obtainable by means of adits.

The coal is similar to that of the Makum field. Analysis (average of 11 samples):—C=57·8: Vol.=34·1: Water=5·5: Ash=2·6 per cent. (**S.** 19).

Singpho Hills.—MAIOBUM (27° 27′: 96° 21′). Two seams of hard bright coal were observed by La Touche (**1034**—7, 112) on the ascent from the Dihing R. to Maiobum, at elevations of 1,300 and 1,800 ft. above the river. The lower seam measured 3 ft. in thickness, and the upper more than 6 ft. (**S.** 16).

BALUCHISTAN.

Bolan Pass.—MACH (29° 52′: 67° 21′). The existence of thin seams of coal at this locality was noticed by Hutton (**900**—8, 570, 601) in 1846. Sections of the strata containing the coal have been given by Griesbach (**708**—4, 22) and King (**987**—46, 6). The seams are numerous, but very thin. None of those exposed near Mach exceeds 2 ft. 8 ins. in thickness (Blanford, **148**—72; —73, 175). The coal bearing rocks are widely distributed along the flanks of the Sor range to the east of the pass, but are greatly contorted and broken up by faulting.

The coal is mined to some extent by petty contractors, the average annual output in recent years being about 8,000 tons. In 1914 8,677 tons were produced, and in 1915, 7,825 tons. It is of poor

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quality, and contains a considerable amount of pyrites. Analysis :—C=41·0 : Vol.=33·1 : Water=10·9 : Ash=15·0 per cent. (**S.** 33).

Sarawan.—JOHAN (29° 20′: 67° 1′). Vredenburg (**1854**—36, 204) mentions the occurrence of a seam of coal, 3 or 4 ft. thick, in the upper part of the Ghazij group, half way between Johan and a place called ZIARAT. The coal is in a very splintery condition, and of poor quality.

ZARAKHU R. (30° 10′: 67° 8′). Two seams of coal, with an average thickness of about 2 ft. 6 ins. and 3 ft. respectively, were found by Oldham in this valley, and were traced eastwards for several miles (*see* King, **987**—46, 8). The quantity available within 400 ft. of the outcrop was estimated at about 300,000 tons. The coal is of better quality than that of Mach. Analysis (average of 2 samples) :—C=44·7 : Vol.=43·3 : Water=7·7 : Ash=4·3 per cent. (**S.** 34).

Sibi.—CHAMARLANG R. (30° 11′: 69° 30′). Ball (**71**—19, 154, 156) has described some seams of coal discovered by Sir R. Sandeman in 1870 in the Luni Pathan country. None of the seams observed exceeded 9 ins. in thickness, but the quality of the coal from the principal seam was good. Analysis (average of 2 samples) :—C=57·8 : Vol.=38·8 : Ash=3·4 : per cent. (**S.** 31).

DUKI (30° 11′: 68° 37′). Seams of coal were found by Oldham (**1324**—37, 29) in several places, but the thickest measured only 14 ins. (**S.** 31).

HARNAI (30° 5′: 68° 0′). Sections of the coal-bearing rocks lying to the W. of Harnai railway station have been described by Oldham (**1324**—32, 108). The principal seams, in layers of coal and carbonaceous shale, are 19 and 20 ins. thick respectively. The coal is of good quality, and makes an excellent coke. Analysis (average of 2 samples) :—C=50·3 : Vol.=36·24 : Water=8·36 : Ash =5·10 per cent.

A 32-inch seam of coal at this locality is now being worked (**S.** 32, 33).

KHOST (30° 13′: 67° 34′). Sections of the coal measures exposed in this neighbourhood were measured by E. J. Jones in 1888, and the prospects of obtaining useful coal were discussed by King (**987**—40, 7 ;—41). The principal seam, with an average thickness of 2 ft. $2\frac{1}{2}$ ins., was traced for a distance of about 2 miles. The quantity of coal available, within a depth of 1,000 ft., was estimated at 565,000 tons.

A colliery was opened by the North-Western Railway Co. in 1877, and now produces about 40,000 tons of coal annually. Mort

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(**1257**) has given a full account of the conditions under which mining is carried on, and of the method of briquetting the dust coal, from 14,000 to 15,000 tons being treated in this manner during the year.

The coal is of fair quality, and cokes well, but it contains a considerable amount of pyrites. Analysis (average of 6 samples) :—C=46·52 : Vol.=41·51 : Water=2·28 : Ash=8·84 per cent. (**S.** 31).

SHARIGH (30° 12′: 67° 42′). A section exposing 30 seams of coal within a vertical thickness of 370 ft. of strata was measured by Blanford in 1881 (**148**—72, 151 ;—73, 191). These included only 4 seams of 12 ins. or more, the thickest measuring 21 ins. Analysis :—C=47·6 : Vol.=40·8 : Water=6·8 : Ash=4·8 per cent. Griesbach (**708**—26, 137) found two seams measuring 2 ft. and 2 ft. 3 ins. respectively in the upper part of the series, and considered that a large amount of coal would be available in this area (**S.** 31).

BENGAL.

Burdwan, RANIGANJ, *see* **BIHAR AND ORISSA, Manbhum.**

Darjeeling.—TINDHARIA (26° 51′: 88° 20′). The existence of carbonaceous shales containing Damuda fossils near PANKABARI (26° 50′: 88° 20′) was recorded in 1849 by Hooker (**867**—6, Vol. I, 403). In 1854 Piddington (**1405**—60) gave an analysis of a specimen of 'earthy soot coal' from the district, which was probably derived from this band. It contained 40·30 per cent. of ash.

In 1874 Mallet traced the band of Damuda rocks from Pankabari eastwards to the neighbourhood of DALING (27° 1′: 88° 46′), a distance of about 30 miles, and examined a large number of outcrops (**1159**—6, 14, 51). Many seams were found, varying in thickness from 2 to 11 ft ; but the intense crushing to which the rocks have been subjected has reduced the coal to the condition of powder. Prospecting operations were carried out in the thick seam exposed at Tindharia, which was proved to a depth of 80 ft. from the outcrop (Mallet, **1159**—10), and experiments on the coking properties of the coal were made.

In 1890-91 Bose carried out an exhaustive exploration of the portion of the band lying between the Lisu and Ramthi rivers, a distance of $2\frac{3}{4}$ miles (**173**—12 ;—15). Numerous outcrops, varying in thickness from 5 to 24 ft., were opened out, and the coal from some of them was found to coke well. The quantity of coal available within a depth of 1,000 ft. from the outcrop, in the central portion of the area examined, measuring 97 acres, was estimated at $5\frac{1}{2}$ million tons, and the total quantity at 20 million tons.

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The coal is of an anthracitic character, and contains only a trace of sulphur. Analysis (average of 8 samples):—C=59·56: Vol.=22·94: Ash=17·42 per cent. (**S.** 35).

BHUTAN.

KALA PANI (26° 55′: 91° 55′). The remains of six lenticular seams of coal, from 2 to 3 ft. in maximum thickness, were observed by Pilgrim (**1406**—7) at a spot where the rocks had been exposed by a landslip. The coal occurs on the same horizon as that of Darjeeling, and is in the same crushed and friable condition. A trial in the furnace of a stationary engine gave satisfactory results. Analysis: —C=54·87: Vol.=19·06: Water=1·82: Ash=24·25 per cent.

BIHAR AND ORISSA.

Hazaribagh.—BOKARO R. (23° 47′: 85° 42′). Specimens of coal from a locality on the Bokaro R., 24 miles to the S. E. of Hazaribagh, were forwarded to the Asiatic Society of Bengal by Drummond in 1838 (**503**). The field was examined in 1852 by Williams (**1935**—2, 21), who found 11 seams of coal aggregating 30 ft. 10 ins. in thickness, of which 20 ft. 10 ins., in 6 separate seams, were considered to be workable. A complete survey was made by Hughes (**888**—2) in 1867. The total area was found to be 220 sq. miles. Seams very numerous, some of them being of great thickness. The eastern portion of the field is said to contain the most valuable seams. Total estimated quantity of coal available, 1,500 million tons. The field is now being exploited (**S.** 55).

CHOPÉ (24° 2′: 85° 17′). The smallest detached coal field in India, occupying about three-fourths of a square mile. Ball, who surveyed the field in 1872 (**71**—14), found only one seam of coal of poor quality, 4 ft. in thickness, and very limited in extent (**S.** 57).

GIRIDIH (24° 11′: 86° 23′) or KARHARBARI (24° 10′: 86° 20′). A report on this field was published in 1850 by McClelland (**1117**—33, 36). Twenty seams of coal were counted, with an aggregate thickness of 92 ft. A seam of excellent coal, 11 ft. thick, was being worked in 1851 (Oldham, **1326**—2, 5). Subsequent reports, giving details of the workable seams, geology, conditions of labour, and quality of the coal, have been drawn up by Smith (**1655**—2, 95), Hughes (**888**—3), and Saise (**1545**—1;—3), as well as a brief description by Cadell (**255**—1).

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The area of the field is about 11 sq. miles, of which 7 sq. miles are occupied by Barakar rocks. The principal seams which have been worked are :—

(1) Karharbari lower seam. Area, 7 sq. miles ; average thickness, 15 ft. 4 ins.; total quantity of coal, 105 million tons.

(2) Karharbari upper seam (now almost exhausted). Area, 150 acres ; average thickness, 6 ft.; quantity, 1½ million tons.

(3) Bhaddoah seam. Area, 913 acres ; average thickness, 6 ft.; quantity, about 11½ million tons.

The remaining seams have an aggregate thickness of 66 ft., but much of the coal in them is of inferior quality.

The field is greatly dislocated by faults and traversed by numerous dykes of basalt and mica peridotite, which have destroyed many thousand tons of coal. The effects of these intrusions have been described by Holland and Saise (**864**) and by Holland and Ward (**865**). They consist in a loss of bituminous matter, with an increase in the percentage of fixed carbon in the coal, and a disproportionate rise in the amount of ash, probably due to the introduction of foreign matter in solution.

Analyses of the seams worked have given the following results :—

(1) Lower seam. C=66·84 : Vol.=24·42 : Ash=9·15 per cent.

(2) Upper seam. C=60·46 : Vol. =28·11 : Ash=11·96 per cent.

(3) Bhaddoah seam. C=61·24 : Vol.=22·96 : Ash=15·84 per cent.

The use of closed ovens for the production of coke and the recovery of the valuable bye-products was advocated by Ward (**1887**—2) in 1904. These have been in successful operation for some years. They produce about 76 per cent. of coke, and 27 lbs. of sulphate of ammonia, per ton of coal.

The output of the field was about 400,000 tons in 1880, and amounted to 872,647 tons in 1915. During the five years 1909 to 1913, the average annual output was 725,136 tons. The principal collieries are owned by the East Indian Railway Co., and the Bengal Coal Co. (**S.** 40).

ITKHURI (24° 18′: 85° 13′). The field is about 15 miles in length, with an average breadth of 1½ mile, but the Barakars occupy only half a square mile of the area. Three seams of coal are exposed, from 4 to 8 ft. in thickness. The coal is of inferior quality, containing over 30 per cent. of ash. Hughes (**888**—8, 321) estimated the maximum quantity available at 2 million tons (**S.** 58).

KARANPURA (23° 50′: 85° 15′). The discovery of a seam of coal, 3 ft. thick and extending over a wide area, near BALLIA (23° 48′: 85°

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19′), was recorded by Dunbar (**510**—2) in 1841. A small portion of the field was surveyed by Williams (**1935**—2, 42) in 1848, when ten seams, with an aggregate thickness of 28 ft. 10 ins., were found.

The field is divided by a narrow band of gneissic rocks into two portions, North and South Karanpura, with total areas of 472 and 72 sq. miles respectively. Hughes (**888**—7), who surveyed both fields in 1871, estimated the area of the coal bearing rocks in the northern field at 371 sq. miles, with an aggregate thickness of coal of 35 ft. The total quantity of coal was estimated at 8,750 million tons. Similar estimates for the southern field were :— Area of coal-bearing rocks, 67 sq. miles ; average aggregate thickness of coal, 50 ft.; total quantity available, 75 million tons.

Analysis of the coal from a seam at GONDALPUR (23° 50′ 30″: 85° 22′) gave the following result :—C=64·5 : Vol.=27·0 : Ash=8·5 per cent. (**S.** 56).

KARHARBARI, *see* GIRIDIH *above*.

RAMGARH (23° 38′: 85° 35′). This field was visited by Williams (**1935**—2, 39) in 1848, but the coal was pronounced to be of poor quality, and no details of the seams were given. A survey was made by Ball (**71**—2) in 1867. The total area of the field is about 40 sq. miles. In the eastern portion the seams are generally thick, but of very variable quality. In the western portion the coal is of better quality, but the seams are cut up by faults and much crushed. The quantity available is probably about 5 million tons (**S.** 56).

Manbhum.—JHARIA (23° 44′: 86° 29′). Specimens of coal from a thick and extensive seam near Jharia were sent to the Asiatic Society of Bengal by Harryngton (**775**) in 1838. The field was surveyed by Hughes (**888**—1) in 1865, when the total quantity of coal available was estimated at 465 million tons; but nearly 30 years elapsed before railway communication was established, and the serious exploitation of what is now the most productive coal field in India was undertaken.

A re-survey of the field was made by Ward (**1887**—1) in 1892. The area occupied by the Barakar group was found to be 150 sq. miles. In this group 17 seams of coal of over 5 ft. in thickness were counted. The quantity contained in Nos. 12 and 13 seams was estimated at 1,277 million tons, and the nett amount available at 864 million tons. The seams in the overlying Raniganj group, which covers an area of 28½ sq. miles, were considered both by Hughes and Ward to be valueless ; but in a summary by Griesbach (**708**—34, 14) of the results of a re-survey made by Stonier in 1902, it is stated that

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two of the seams near the base of the group have been found to be workable. An additional seam, No. 18, was discovered in the Barakar group during the progress of this survey (**S.** 49).

A description of the field, and of the system of mining adopted, has recently been published by Greenwell (**701**).

The following analyses are given by Ward :—

No. 12 seam. C=61·36 : Vol.=26·28 : Ash=12·36 per cent.
No. 13 seam. C=59·12 : Vol.=29·05 : Ash=11·83 per cent.
No. 17 seam. C=57·58 : Vol.=32·19 : Ash=10·23 per cent.

A table of analyses of samples selected under the superintendence of E. P. Martin and Prof. H. Louis is given by Holland (**859**—48).

The output of the field has increased steadily since 1894, when about 15,000 tons of coal were produced. The average annual output for the five years 1909 to 1913 was 6,852,556 tons. In 1915 it amounted to 9,140,800 tons.

RANIGANJ (23° 36′: 87° 8′). This is the largest of the Damuda valley coal fields, covering an area of about 500 sq. miles. It was also the first to be exploited. A colliery was opened in 1774 at AITURA, on the Barakar R., by Messrs. Sumner, Heatly, and Redfearne, who obtained an 18 years' lease of the property; but the first consignment of coal sent to Calcutta met with an unfavourable report, and the enterprise was abandoned (Heatly, **801**).

About the year 1815 the first shafts were sunk at Raniganj by Mr. Jones, owner of the Albion Mills, Calcutta (**956**—1). Eight seams of coal, including two of 8 and 9 ft. in thickness, were passed through within a depth of 88 ft. Mr. Jones at the same time proposed a scheme, which was afterwards adopted, for the transport of coal to Calcutta by water (**956**—2, 285).

The first survey of the field was made in 1842 by Homfray (**866**—1), who traced its boundaries and the course of the principal igneous dykes. The distinction in age between these coal measures and those of Assam was also pointed out.

A report by Williams (**1935**—1, 17) in 1850 gives details of the outcrop and quarry sections. Eighteen seams were counted in the lower coal measures, and thirty-two in the upper, with an aggregate thickness of 353 ft. 7 ins. of coal.

In 1858-60 Blanford (**148**—7) carried out a complete survey of the field, and established a standard classification of the rock groups comprised in the lower Gondwana system. In the upper, or Raniganj group, nine seams, with an aggregate thickness of 120 ft., were being worked in the eastern portion of the field; and eleven

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seams, with an aggregate thickness of about 100 ft., in the western. In the lower, or Barakar group, four seams aggregating 69 ft. in thickness were being worked. The course of the principal faults was laid down, as well as that of the numerous dykes of basalt and mica peridotite which are intrusive in the coal measures, and as in the Giridih and Jharia fields, have destroyed an immense amount of coal. The total quantity of coal contained in the field was estimated at 21,671 million tons.

A general account of the coal fields in the Damuda valley, with special reference to the systems of mining adopted at several of the collieries, has been given by Stonier (**1715**—5), who, in collaboration with Saise, has also published a revised map of the field (**1715**—6).

A re-survey of the field has recently been made by a Committee of the Mining and Geological Institute of India, and has confirmed the general accuracy of Blanford's work (Walker, **1869**). In the Barakar group several thick seams have been discovered during the interval; but it has become evident that the seams are variable in thickness, and that the thick seams do not occur at the same horizon in the eastern and western portions of the field. Some were found to thin out in passing from east to west, and others in the opposite direction; while one seam, the Sanctoria, was found to attain its greatest thickness in the centre of the field.

The dimensions, etc., of the most important seams are shown in the following table. The quantities available are estimated on the assumption that the seams can be worked to a distance of 2 miles from the outcrop:—

Quality.	Seam.	Average thickness.	Length of outcrop.	Total quantity available.
		Feet.	Miles.	Million tons.
	DISHARGARH . .	18	12	300
First class . .	SANCTORIA . .	10	2	30
	SIBPUR . . .	15	9	188
	GHUSIC . . .	12	3	50
Medium class .	RANIGANJ . .	15	2	40
	LAIKDIH-SALANPUR. (*Barakar*)	20	10	270
	TOTAL .	..	..	878

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Analyses of 31 samples by Tween in 1877 (**1820**—4) gave the following average result :—C=53·20 : Vol.=25·83 : Water=4·8 : Ash=16·17 per cent.

A series of analyses made by Saise was published by Holland (**859**—46) in 1904. From these it appears that there is a progressive increase in the amount of moisture and volatile matter in passing from the lower to higher stages, with a corresponding decrease in the proportion of fixed carbon. The average values obtained were :—

——	Barakar.	Raniganj lower seams.	Raniganj upper seams.
	Per cent.	Per cent.	Per cent.
Water	1·06	3·76	6·82
Volatile matter	25·96	31·51	32·18
Carbon	56·22	49·67	44·76
Ash	16·75	15·05	16·24

The following calorific values have been obtained by Hughes (**885**—3) :—

——	Calculated.	By experiment.
	Calories.	Calories.
A. Raniganj (22 samples)	6,835	6,767
B. Barakar (3 samples)	7,571	7,348

The coals determined had the following average composition :—

A. C=53·42 : Vol.=32·16 : Water=4·76 : Ash=9·66 per cent.
B. C=64·05 : Vol.=24·76 : Water=1·65 : Ash=9·54 per cent. (**S.** 43).

The following statistics of output have been published at various periods :—

1815-23. Herbert (**827**—4). Average for 9 years, about 400 tons.

1832. Johnston (**947**—1, 317). From 10,000 to 14,000 tons annually.

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1858-60. Blanford (**148**—7, 183). Average for 3 years, 281,995 tons, from 42 collieries. In 1910 the number of collieries had increased to 206. The average annual output for the five years 1909 to 1913 was 4,566,198 tons. In 1915 it amounted to 5,484,596 tons.

Palamau.—AURUNGA R. (23° 49′: 84° 20′). This field was surveyed in 1878 by Ball (**71**—32, 55). The total area is 97 sq. miles; but workable coal is confined to the rocks of the Barakar group, which cover an area of 58½ sq. miles. The sections exposed show numerous seams of coal and carbonaceous shale, but only three are worthy of consideration. The total quantity of coal contained in these was estimated at 20 million tons.

The quality of the coal is poor. The average values obtained from 7 samples were:—C=36·5: Vol.=29·2: Water=6·7: Ash=27·5 per cent. (**S.** 58).

DALTONGANJ (24° 2′: 84° 7′). Coal of poor quality was discovered on the Amanat R. near SINGRA (24° 7′: 84° 6′) by Franklin (**616**—5;—6) about the year 1829. An attempt was made in 1840 to open up the seam, when about 35 tons were extracted and sent to Dehri-on-Son (Ravenshaw, **1461**—1).

The prospects of exploiting the field were discussed by Tytler (**1824**—2) and Sage (**1541**) about the year 1840, and collieries were soon afterwards opened by the Bengal Coal Co. at RAJHARA and PANDUA, on the northern edge of the field. Brief accounts of the operations of the Company have been given by Smith (**1655**—1, 80) and Thompson (**1771**—2, 11). Considerable quantities of coal are said to have been extracted and sent down to the towns on the Ganges during the rainy season.

In 1872 the field was fully surveyed by Hughes (**888**—9). The total area is about 200 sq. miles, of which only 30 sq. miles are occupied by the Barakars. The seams exposed near Singra were found to vary both in thickness and quality; but the one which had been worked near Rajhara, with an average thickness of 6 ft., was estimated to contain 11,600,000 tons of useful coal.

Grant (**693**) gives sections of two borings put down on the JINJOI R. in 1883, and estimates the quantity of coal in the field at 23 million tons. A much higher estimate, amounting to no less than 161,377,000 tons containing 11·7 per cent. of ash, was made by Saise as the result of a partial exploration in 1890.

A series of borings put down in 1891 by the Public Works Department showed that although two distinct seams occur over nearly the whole of the area, the coal is for the most part of such inferior quality that only a very small proportion is of economic value. It

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was estimated that about 9 million tons of fair quality might be obtained from an area of one sq. mile near Rajhara (La Touche, **1034**—18).

Analyses of 2 samples from the Rajhara seam gave the following average result :—C=49·37 : Vol.=27·63 : Water=8·40 : Ash=14·60 per cent.

Railway communication with the field was opened in 1901. The average annual output for the five years 1909 to 1913 was 79,442 tons. In 1915 it amounted to 85,785 tons (**S.** 59).

HUTAR (23° 50′: 84° 7′). One of Rennell's maps (**1473**—1, No. VIII), published in 1781, contains the legend 'Cole mine' in the approximate position of this locality. Sage in 1830 discovered a seam of good coal, 3 ft. 9 ins. thick, on the GHORASAN R., a tributary of the Koel (Franklin, **616**—6, 219).

Ball (**71**—32, 91) made a complete survey of the field in 1878. The total area was found to be about 78 sq. miles, of which 57 sq. miles are occupied by the Barakar group. Three seams of useful coal were met with, measuring from 8 ft. to 13 ft. 8 ins. in thickness; but the area over which they extend could not be ascertained, and it was not found possible to make any reliable estimate of the quantity available.

The coal is said to be of average Indian quality. The average composition of 8 samples was :—C=55·35 : Vol.=28·0 : Water=5·95 : Ash=10·7 per cent. (**S.** 59).

Santal Parganas.—In the course of a geological survey of the Rajmahal hills, carried out in 1869-70, Ball (**71**—26, 179) examined the outcrops of coal known to occur in that area. A list of the seams exposed, with particulars of their thickness and quality, is given on pp. 230-235 of his memoir. The area over which the coal bearing Damuda rocks are exposed extends along the western border of the hills, and was estimated to cover about 70 sq. miles. It is not known how far these rocks extend eastwards, where they are concealed by thick flows of basalt. The total quantity of coal available over the exposed area, assuming the existence of a seam 5 ft. in thickness, was estimated at 210 million tons.

A general account of the coal fields in these hills had previously been given by Oldham (**1326**—6, 275).

The following coal fields situated in the district have been described :—

BRAHMINI R. (24° 17′: 87° 32′). Discovered by Pontet in 1838. Some coal was raised but was of poor quality (Ball, **71**—26, 182). Analysis :—C=38 : Vol.=42 : Ash=20 per cent.

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CHAPARBHITA (24° 47′: 87° 29′). Discovered by Sherwill in 1851 (**1625**—9, 573). Seams of 6 ft. and 4 ft. occur, but were not considered to be worth working.

DUBRAJPUR (24° 25′: 87° 32′). Sherwill (**1625**—9, 598) describes seams from 1 ft. 2 ins. to 3 ft. in thickness, but according to McClelland (**1117**—33, 44) none is of workable quality.

GILHURRIA (24° 51′: 87° 28′). Two seams 6 ft. and 3 ft. thick respectively were found by Stuart (**1723**—4) in a small patch of Damuda rocks. Analysis:—C=39·67: Vol.=30·94: Water=7·46: Ash=21·92 per cent.

HURA (24° 59′: 87° 27′). Several seams occur, but are of poor quality. About 40,000 tons of coal were extracted in the years 1859-60 (Oldham, **1326**—52, 149). Borings put down in 1890 (King, **987**—46, 3) failed to detect the presence of good coal (Ball, **71**—26, 194).

JAINTI (24° 10′: 86° 46′). Area of Barakar rocks about 5 sq. miles. Seams of coaly shale occur, none over 3 ft. thick (Hughes, **888**—4, 249).

KUNDIT KARAIA (23° 58′: 87° 13′). Area of Barakar rocks about 1½ sq. miles. Two seams occur, one of 1 ft. 2 ins. containing fair coal (Hughes, **888**—4, 254).

PACHWARA (24° 30′: 87° 28′). This was considered by Oldham (**1326**—6, 275) to be the most promising of the Rajmahal coal fields; but Ball (**71**—26, 187) says that the beds are so disturbed, and the area so small, that they can never produce any considerable amount of coal. The quality also is very poor.

SAHAJORI (24° 8′: 86° 54′). Area covered by Barakar rocks, about 5 sq. miles. Sections few and imperfect. Samples analysed by Waldie contained 37 per cent. of ash (Hughes, **888**—4, 253).

The average composition of 13 samples of coal from various localities in the Rajmahal hills was found to be:—C=42·13: Vol.=39·50: Ash=18·37 per cent. (**S.** 38).

Talcher.—TALCHER (20° 57′: 85° 18′). A discovery of coal on the Talcher estate in Cuttack was reported in 1827 (**35**—17). Subsequently, in 1837-39, Kittoe announced (**994**—1;—3, 1062;—4, 141) the discovery of coal seams on several of the streams flowing into the Brahmini R. One seam, 18 ins. thick, was said to be of fair quality.

In 1855 the field was surveyed by W. T. Blanford, H. F. Blanford, and Theobald (**150**) with disappointing results, summarised by Oldham in the first paper published in the Memoirs of the Geological Survey (**1326**—10). The total area of the field was found to be

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about 700 sq. miles. A thick seam at GOPULPERSAD (20° 58′: 85° 6′), favourably mentioned by Samuells (**1550**), was found to consist of carbonaceous shale, with strings of coal not more than 3 ins. in thickness: and no seam of workable coal was met with elsewhere. A brief description of the field was afterwards given by W. T. Blanford (**148**—35, 63), who suggested sites for borings; but no further action appears to have been taken.

Specimens of the coal examined by Piddington (**1405**—67) were found to contain over 30 per cent. of ash (**S.** 37).

BOMBAY.

Cutch.—BHUJ (23° 15′: 69° 44′). The occurrence of a bed of lignitic coal near Bhuj was noted by Macmurdo in 1818 (**1145**—1, 209). Borings were put down near SISAGADH (23° 6′: 69° 24′) in 1834 and 1835 by Grant (**691**—1;—2;—3, 293) in the hope of finding workable seams, but without success. An attempt was made to work a bed of coal at TROMBOW (TRAMBAU, 23° 19′ 30″: 69° 48′) but the seam was only 16 ins. thick, of which only half was good coal (Blanford, **148**—15, 23).

The coal is of Jurassic age. According to Wynne (**1975**—8, 58; —11, 86), the seams thin out rapidly, and there is no prospect of obtaining useful coal either from these beds or from the overlying Tertiary rocks, among which thin layers of coaly shale also occur (**S.** 61).

Kathiawar.—THAN (22° 34′ 30″: 71° 15′ 30″). Black carbonaceous shale with thin strings of coal near this place have given rise to reports of the occurrence of coal in the province (Fedden, **569**—6, 82, 133). The deposit is of no value as fuel (**S.** 61).

Sind.—LAINYAN (25° 40′: 68° 13′). Coal was found in a shaft sunk at this place, at a depth of 64 ft. from the surface, in 1857 (Phillips, **1100**). The seam when opened out was 5 ft. 9 ins. thick, but according to Blanford (**148**—14, 13) it thins out rapidly in all directions, and was soon exhausted (**S.** 60).

BURMA.

Bhamo.—MITHWÉ (24° 5′: 96° 59′). This field was examined in 1896 by Hayden (*see* Oldham, **1324**—52, 6). Coal occurs in thin seams, the best of which is 2 ft. 8 ins. thick, but is shaly and poor. The beds (Tertiary) are highly disturbed and crushed, and penetrated by igneous intrusions (**S.** 74). An output of 25 tons of coal is reported for the year 1915.

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Chindwin (Upper).—KALÉ R. (23° 11′: 94° 20′). Two specimens of coal said to have come from the Chindwin R., were examined by Piddington (**1405**—64) in 1854. One of them is described as an excellent steam coal, containing:—C=67·85: Vol.=26·50: Water =4·25: Ash=1·40 per cent. The other is called a jet coal, and contains 23·40 per cent. of ash.

A section on the KALÉ R., above its confluence with the Chindwin, was examined by Jones (**952**—4, 172) in 1887. Ten seams were found in an area of a square mile, all of which, except one 10 ft. thick, were considered to be useless. A more detailed survey by Noetling (**1311**—14) showed that the field has a wide extension. The coal measures occupy the valleys of the Nantahin, Peluswa, Maku, and Telong streams, to the N. of the Kalé, for a distance of 55 to 60 miles. In the Maku valley the aggregate thickness of coal available was estimated at 24 ft. The Nantahin-Peluswa tract which was more thoroughly surveyed, was found to cover an area of about 25 sq. miles, with a total thickness of coal of 48 ft. Assuming that this could be worked to a depth of 1,000 ft. from the outcrop, the total available yield would be 210 million tons.

The field has not yet been developed. In the course of prospecting operations 1,222 tons of coal were extracted in 1906 from a 10 ft. seam exposed on the Kalé R. near KALEWA (**861**, 67).

The average composition of the coal, as shown by 13 samples, is:—C=49·95: Vol.=34·59: Water=10·14: Ash=5·30 per cent. (**S.** 72).

Henzada.—Three occurrences of coal in this district have been described by Romanis (**1511**—5) and Stuart (**1723**—9, 254). The localities are:—

HLEMAUK (17° 50′: 95° 6′ 30″). Outcrop of coal about 20 ins. in thickness. The quality is very poor, owing to a large percentage of iron pyrites. The seam apparently extends for several miles to the south, to KYIBIN, but consists only of carbonaceous shale.

KYWEZIN (17° 58′ 30″: 95° 9′). Seam at the outcrop about 10 ft. in thickness with a high easterly dip. The beds are much faulted and contorted, and the coal is greatly crushed. Analyses show a high proportion of fixed carbon. Average of 3 samples:—C=74·44: Vol.=17·59: Water=1·68: Ash=6·29 per cent.

Practical tests gave disappointing results: for though it was found to be an excellent smithy coal, a full pressure of steam could not be kept up in the boiler of an engine.

POSUGYI (18° 10′: 95° 7′ 30″). The seam at the outcrop varies from 6 to 20 ins. in thickness. The outcrop is close to a main fault and

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the beds are greatly contorted. Analysis :—C=69·65 : Vol.=18·21 : Water=6·36 : Ash=5·78 per cent. (**S.** 64).

Katha.—PINLEBU (24° 5′ : 95° 24)′. Several outcrops were found by Noetling (**1311**—18, 120) in this neighbourhood. Most of them are too thin or too poor in quality to be of value. The best occurs near YUYINBYET, S. of Pinlebu, and is 4 to 5 ft. thick. Analysis :—C=52·22 : Vol.=34·24 : Water=6·60 : Ash=7·04 per cent. (**S.** 74).

Kyaukpyu.—CAP I. (19° 26′: 93° 31′). A discovery of coal here attracted some attention in 1841-42 (Spry, **1687**—6, 144 ; Hinton, **838**). The seam is said to be very irregular, and to dip at a high angle. It was evidently of no economic value.

CHEDUBA I. (18° 50′: 93° 40′). Mallet (**1159**—14, 209) describes a seam, 2 ft. 6 ins. thick, near PALLANG ROA, in the southern part of the island. The coal was very brittle. A seam mentioned by Halstead (**742**, 23) as occurring near the coast in the Tangroa circle is merely a carbonaceous sandstone (**S.** 68).

RAMRI I. (19° 5′: 93° 50′). In 1833-34 the discovery of coal at three localities in the island was reported by Foley (**595**—1 ;—2). The seam at one of these, SYNKYAUNG near Kyaukpyu, is stated by Prinsep (**1436**—16) to be from 6 ins. to a foot thick. Analysis :—C=67·0 : Vol.=29·0 : Ash=4·0 per cent.

In 1878 all the known outcrops were examined by Mallet (**1159**—14). The occurrences mentioned by Foley were found to be mere nests or lenticular seams of lignite. A true seam, 6 ft. thick, was found near TSETAMA (18° 57′: 93° 56′), but with a high dip and of small extent. The coal is very soft and friable. Analysis :—C=38·4 : Vol.=28·9 : Water=14·6 : Ash=18·1 per cent. (**S.** 67).

Mergui.—The existence of coal on the Great and Little Tenasserim rivers was brought to notice by Helfer (**808**—3 ;—5, 36) in 1838-39. On the latter river he described outcrops of a seam 6 ft. thick, exposed at several places near TSINGKOON (12° 1′: 99° 6′), and estimated the total quantity available at 3,600,000 tons. He considered the coal exposed on the Great Tenasserim R. to be of no value, but in a later paper (**808**—4) he mentioned an outcrop at TA-THE-NA (? THATAY-KYAUNG or TENDAU, 12° 20′: 99° 10′), showing over 6 ft. of coal of fair quality, though much contaminated by pyrites. A scheme for working the coal was proposed by Hutchinson (**899**), and in 1840 prospecting operations were undertaken by Government (Cullen, **397**—3 ; Tremenheere, **1802**—5). A considerable quantity of coal appears to have been raised ; but the loss of a vessel laden with Mergui coal,

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through spontaneous combustion of the cargo, led to the abandonment of the mines (O'Riley, **1340**—3, 738).

In 1856 most of the outcrops were visited by Oldham (**1326**—13). The thickness of the seams at Tsing-koon is said to have been exaggerated, but two seams of 2 ft. and 3 ft. were found, containing coal of fair quality. On the Great Tenasserim seams of 6 ft. to 17 ft. 6 ins. in thickness were met with at three localities. The quantity available was estimated at 19,360 tons per acre over an area of 4 sq. miles.

Some years later the prospects of re-opening the mines at Thatay-Kyaung were discussed by Harrison (**774**) and Fryar (**625**—4); but no further steps were taken till 1892, when Hughes (**888**—32) reported on a seam 12 ft. thick, including 7 ft. 7 ins. of good coal, on the Hti-phan-ko stream, a tributary of the Great Tenasserim N. of KAMAPYING (12° 27′: 99° 8′).

In the following year, Bose (**173**—18) carried out a detailed survey of the field, to which the name Tendau-Kamapying was given. Coal was found in beds both of Carboniferous and Tertiary age, but that in the former is said to be of no value. The Tertiary coal measures cover an area of about 30 sq. miles; but the outcrops examined are restricted to the neighbourhood of Tendau and Kamapying respectively. In the Kamapying area a seam with an average thickness of 15 ft. was found to extend for about three quarters of a mile, and the quantity available within a vertical depth of 200 ft. was estimated at 600,000 tons. In the Tendau area the average thickness of the seam was taken to be 4 ft., and the quantity available within the same vertical depth was estimated at 380,000 tons.

The following analyses of the coal have been made:—

TSING-KOON. C=50·3: Vol.=49·7: Ash=8·5 per cent.

KAMAPYING. C=44·24: Vol.=35·08: Water=16·40: Ash=4·28 per cent.

Practical tests of the Tendau coal, carried out by Johnston (**947**—2) in 1839, are said to have given satisfactory results, as compared with Raniganj coal (**S.** 61).

LENYA R. (11° 25′: 99° 0′), A-TONG-WO. An outcrop on the Phlia stream, 8 miles above Lenya, was described by Oldham (**1326**—13). The seam is very irregular, varying from 1 ft. to 2 ft. 6 ins. in thickness. The coal ignites with some difficulty, but can be obtained in large solid masses. It contains numerous lumps of amber-like resin (**S.** 64).

Pakokku.—YAW R. (21° 18′: 94° 20′). This field was surveyed in 1914 by Cotter and Sethu Rama Rau (**372**—11). The coal seams

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occur in the lowest subdivision of the Pegu series, and are of Miocene age. Outcrops occur in two main areas :—

1. LETPANHLA field. Numerous seams are exposed, and have been examined for a length of about 1½ miles. The main seam was found to be from 5 to 6 ft. thick, but it contains numerous partings of shale.

2. TAZU field. Three fairly good seams are exposed in places, but the thickness varies considerably. The lowest seam is 7 ft. thick at one point, but contains frequent partings of shale. The highest seam increases in thickness from north to south, but does not contain more than 2 ft. 7 ins. of coal.

The coal contains a high percentage of moisture. Analyses of 22 samples gave the following average composition :—C=35·86 : Vol.=34·15 : Water=18·73 : Ash=11·28 per cent.

Shan States (N.).—The coal measures of the Northern Shan States occupy a series of detached basins grouped around the base of Loi Ling, the loftiest mountain in the States. The beds in which the coal is found are probably of lacustrine origin, and of late Tertiary age (La Touche, **1031**—45, 309, 367). The following areas have been examined :—

LASHIO (22° 56′: 97° 47′). The coal field lies in the valley of the Namyau R., about 5 miles to the N. of the town. It was visited in 1891 by Noetling, who recorded the existence of several outcrops (**1311**—4) indicating the presence of a seam extending for about 2 miles, and in one place at least 30 ft. in thickness.

In 1904-05 the field was surveyed by La Touche and Simpson (**1037**), and at the same time some prospecting work was undertaken by the Burma Railways Co. The area of the field is about 50 sq. miles, but the coal is exposed only along its southern edge, in the bed of the Namyau and the streams which join it from the north. Coal was found in seven places, varying in thickness from a foot to 33 ft.; but it was not found possible to say whether a continuous seam exists or not, or to make any estimate of the total quantity available, on account of the lenticular character of the seams opened up by the excavations.

The coal is a brownish black lignitic variety, with a distinctly woody texture, and on exposure to the air it quickly breaks up into small cuboidal fragments. On trial it was condemned as a locomotive fuel. Its average composition, as shown by analysis of 6 samples, is :—C=31·08 : Vol.=35·63 : Water=20·65 : Ash=12·64 per cent. (**S.** 70).

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MAN-SANG (22° 26′: 97° 58′). Surveyed by Simpson (**1640**—6, 144) in 1905. The area of the field is about 13½ sq. miles. Numerous outcrops were found, but none exceeds 4 ft. 6 ins. in thickness. The coal is a hard shaly lignite, disintegrating rapidly on exposure to the air. Average analysis (6 samples):—C=36·32: Vol.=35·13: Water=14·23: Ash=14·32 per cent. (**S.** 71).

MAN-SE-LÉ (22° 40′: 98° 16′). Surveyed by Simpson (**1640**—6, 152) in 1905. Total area about 13½ sq. miles. Coal was found in six or seven places, but there appears to be only one seam of workable coal, of small average thickness. A sample from a seam 3 ft. 2 ins. thick yielded on analysis:—C=34·22: Vol.=38·83: Water=14·73: Ash=12·22 per cent. (**S.** 71).

NAMMA (22° 42′: 97° 52′). This field was visited in 1891 by Noetling (**1311**—4, 116), who thought that he could detect the presence of ten seams, each of which was not less than 5 ft. thick, containing coal of excellent quality.

A thorough examination of the field was carried out by Simpson (**1640**—6, 125) in 1905, when the most promising seams were proved by excavation. The total area of the field is about 50 sq. miles. Only two seams of economic importance were found. One of these, varying in thickness from 7 to 17 ft. was traced for a distance of about half a mile near Namma. The other, exposed near MONG-TING, about 5 miles to the N. E. of Namma, has a maximum thickness of 5 ft., but quickly thins out, and is of inferior quality. It was estimated that the Namma seam would yield about half a million tons.

The coal is somewhat harder than that of the Lashio field, but becomes brittle when dry. The average composition of 5 samples was:—C=38·81: Vol.=36·90: Water=16·58: Ash=7·71 per cent. (**S.** 70).

WETWIN (22° 5′ 30″: 96° 38′ 30″). Three outcrops of coaly material, situated 9 miles to the east of the Mandalay-Lashio railway at Wetwin, were examined in 1914 by Coggin Brown (*see* Middlemiss, **1219**—31, 112). The age of the coal could not be determined, but it resembles the Tertiary coal of Lashio in composition. It has a dull black colour, and quickly crumbles to powder on exposure to the air. No estimate of the quantity available is possible without excavations or borings. Average analysis (3 samples):—C=33·59: Vol.=38·38: Water=16·39: Ash=11·61 per cent.

Shan States (S.).—LEGAUNG (20° 50′: 96° 33′). A thin seam of coal is mentioned by Jones (**952**—4, 188) as occurring here and at TITPALWIGON, about one mile distant. The coal is very powdery

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and of poor quality. Average analysis (2 samples) :—C=70·43 : Vol.=12·50 : Water=2·08 : Ash=14·99 per cent. (**S.** 69).

PANLAUNG R. (21° 5′: 96° 20′). This field was surveyed by Jones (**952**—4, 177) in 1887. Total area, from 150 to 200 sq. miles. Numerous groups of outcrops occur, but the seams are all thin and irregular, and none holds out any prospect of being workable. The beds are highly disturbed, and the coal greatly crushed. Average analysis (8 samples) :—C=65·81: Vol.=16·86 : Water=4·82 : Ash=13·01 per cent. (**S.** 69).

PWEHLA (20° 51′: 96° 43′). A seam of shaly coal, varying from 7 to 11 ft. in thickness, has been described by Jones (**952**—4, 189) as occurring at NGU or NGOTKO-YAYGI, 7 to 9 miles to the N. W. of Pwehla. The seam contains a large quantity of pyrites. Middlemiss (**1219**—22, 149) describes the seam as consisting of graphitic shale, of no value as fuel (**S.** 69).

THAMAKAN (20° 42′: 96° 42′). A seam at PO-PYU, 8 miles to the S. W. by S. of Thamakan, has been described by Middlemiss (**1219**—22, 150). At one spot it is 3 ft. thick, and seems to be fairly continuous along the strike. The coal appears to be very good, but friable (**S.** 70).

Shwebo.—KABWET (22° 44′: 95° 59′) or THINGADAW (22° 57′: 96° 0′). In 1855 Oldham (**1326**—17, 332) described outcrops of coal at three localities in the neighbourhood of Thingadaw on the Irrawaddy. These were :—

TEMBIUNG. Seam 4 ft. thick, including 1 ft. 3 ins. of coal of poor quality.

KIBIUNG STREAM, 5 miles W. of THINGADAW. Seam 5 ft. 6 ins. thick, including shaly layers. Coal flaky and woody with much fossil resin.

Locality 8 miles N. W. of THINGADAW. Seam about 4 ft. thick, exposed for about 200 yards. Coal hard and jetty with much resin.

Coal was being mined at LETKOBIN and KETZUBIN, near Kabwet, when Anderson visited the locality in 1870 (**29**—2, 198). The seam worked was about 6 ft. thick, but much of the coal was of poor quality. King (*Records, G. S. I.*, XXVII, 33), after an inspection of the field in 1894, considered that the area over which coal of good quality occurs is very restricted, and thought that the quantity available would not be more than 150,000 tons. The output of the mines was then from 10,000 to 15,000 tons annually. It reached a maximum of nearly 23,000 tons in 1896, but after considerable fluctuations the mines were closed in 1904.

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A representative sample from LETKOBIN has the following composition :—C=36·22 : Vol.=37·68 : Water=11·94 : Ash=14·16 per cent. (**S.** 71).

Thayetmyo.—KYAUK-KALÁ (19° 27′: 94° 44′). A bed of carbonaceous shale, containing a one-foot seam of hard bright coal, is mentioned by Theobald (**1763**—16, 342). The seam has a very high dip, and is probably worthless. This occurrence is also mentioned by Ranking (**1458**, 57).

THAYETMYO (19° 19′: 95° 14′). An outcrop of coal on the 'Lime Hill,' about 5 miles to the S. of Thayetmyo, was discovered in 1855 by White (**1921**). On examination in the same year by Oldham (**1326**—14), the seam proved to be very irregular in thickness, decreasing from about 4 ft. at the outcrop to about 20 ins. within 14 ft. from the surface. Subsequent exploration confirmed the opinion then expressed that the deposit is of little value (Romanis, **1511**—9, 150).

A sample of the coal analysed by Piddington (**1405**—75) gave the following result :—C=64·10 : Vol.=30·25 : Water=2·50 : Ash =3·15 per cent. Trials carried out in 1855 by Jones (**954**) showed that it compared favourably with Raniganj coal (**S.** 65).

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Rewah.—JOHILLA R. (23° 24′: 81° 5′). The occurrence of fragments of coal in the Johilla R. was noted in 1840 by Spilsbury (**1684**—10, 901). In 1881 a section in the bed of the river near PALI was described by Hughes (**888**—24, 127), who afterwards made a detailed survey of the field (**888**—29, 169).

The coal measures are exposed in two separate tracts. The southern has an area of 3¼ sq. miles, but no indications of a workable seam were found in it. The area of the northern tract is 11½ sq. miles. Borings proved the existence of at least two seams, 17 ft. and 6 ft. thick respectively, at two localities. The quantity of coal available was estimated with some reserve at about 100 million tons. Analyses of 3 samples of the coal gave the following average result :—C=54·43 : Vol.=34·85 : Ash=10·72 per cent. (**S.** 77).

KORAR (23° 38′: 80° 56′). Surveyed by Lala Hira Lal (*see* Hughes, **888**—29, 165) in 1882. Total area 9½ sq. miles. Few outcrops were found, but a boring at JAWALA MUKHI, between Korar and Kotalwar, proved the existence of four seams, 8 ft., 4 ft., 4 ft., and 7 ft. thick respectively. A sample from one of the outcrops yielded on analysis :—C=65·48 : Vol.=12·56 : Water=5·04 Ash=16·92 per cent. (**S.** 77).

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SINGRAULI. A discovery of coal near KOTA (24° 6′: 82° 45′) was reported by Wroughton (**1974**) in 1840. Prospecting pits were opened and a seam about 4 ft. thick, with several bands of bituminous shale, was proved. The workings were still being carried on in 1855-57, when reports on the field were made by Roberts (**1492**) and Smith (**1655**—2). The latter mentions the occurrence of a 6 ft. seam at NAWA NAGAR, 6 miles to the S. W. of Kota, and of a quarry at PADRI, about 12 miles further west, in a seam 21 ft. thick.

Griesbach (**708**—28, 117) records the discovery by Oldham of two seams, 6 ft. and 5 ft. 6 ins. thick respectively, near AMLIA (24° 2′: 82° 29′). The area of the field is said to be about 200 sq. miles.

The average composition of two specimens obtained by Wroughton was :—C=54·65 : Vol.=43·35 : Ash=2·00 per cent. Analyses of the coal discovered by Oldham are said (**1324**—52, 4) to have given poor results (**S.** 79).

SOHAGPUR (23° 19′: 81° 25′). This is the largest of the Rewah coal fields, covering an area of nearly 1,600 sq. miles. A seam near the junction of the TIPAN stream with the Son, 30 miles to the S. E. of Sohagpur, was discovered by Franklin (**616**—6, 218) in 1830. Several outcrops of seams over 5 ft. in thickness were described by Hughes (**888**—24, 316) in 1881, and a detailed account of the field was published in 1885 (**888**—29, 177). Numerous outcrops, a list of which is given at p. 236 *seq.* of the memoir, were observed, but the number of seams that contain useful coal is not large. The most important is about 5 ft. in thickness, and was traced from its appearance near BARGAON (23° 11′: 81° 40′) for a distance of about 10 miles. This seam was more recently examined by Reader (**1466**—2), and found to vary in thickness from 13 ft. 8 ins. to 4 ft. 8 ins. An average analysis of 3 samples gave :—C=57·7 : Vol.=26·4 : Water=3·7 : Ash=12·2 per cent. Other promising seams examined were :—

NANDNAH (23° 20′: 81° 32′). Three seams, 5 ft., 4 ft. 6 ins. and 3 ft. 6 ins. thick respectively. Traced over a large area. Analysis (average of 2 samples) :—C=62·69 : Vol.=25·20 : Ash=, 12·11 per cent.

BHALMURI (23° 11′: 82° 9′ 30″). Seam 7 ft. 2 ins. thick ; exposed for a mile and a half. Analysis :—C=59·6 : Vol.=28·2 : Water=6·7 : Ash=5·5 per cent.

SABO (23° 14′: 81° 39′). Seam 4 ft. 3 ins. thick. Analysis :—C=60·8 : Vol.=21·4 : Water=1·0 : Ash=16·8 per cent.

No estimate of the quantity of coal available has been made, but since the dip of the strata is low, there is no doubt that a very large amount can be obtained within a moderate depth (**S.** 78).

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UMARIA (23° 32′: 80° 54′). Spilsbury in 1840 (**1684**—10, 901) noted the occurrence of coal on the Umrar R. near Umaria. The field was surveyed between 1881 and 1884 by Hughes, and at the same time prospecting operations were undertaken, the progress of which was noted from time to time in the Geological Survey Records (**888**—24, 314;—26;—27;—28). The final results were embodied in a memoir (**888**—29, 154, 211).

The exposed area of the field is 6 sq. miles. Seams aggregating 20 ft. in thickness were proved over an area of 4 sq. miles, and the amount available in this portion of the field was estimated at 55 million tons. Subsequent mining work has proved the existence of six seams, four of which, varying in thickness from 3 ft. to 12 ft., are being worked.

The first shafts were sunk in 1884, when the output was 1,600 tons. For about 20 years it steadily increased to a maximum of 193,277 tons in 1903; but since then it has been subject to considerable fluctuations, owing to the opening up of coal fields more readily accessible to the Great Indian Peninsula Railway, the principal consumer. The average annual output for the five years 1909 to 1913 was 138,870 tons. In 1915 it amounted to 139,680 tons.

A representative sample from the seam originally worked yielded on analysis:—C=66·71: Vol.=19·71: Water=5·46: Ash=8·12 per cent. It is, however, said that the coal won in recent years is not up to this standard. Steam trials of a consignment of coal from the outcrop, recorded by Hughes (**888**—29, 216), are said to have given very satisfactory results (**S.** 75).

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Betul.—LOKARTALAI (22° 22′: 77° 30′). A band of shale exposed on the Moran R., containing a seam of bright coal 4 ft. thick, is mentioned by Medlicott (**1197**—22, 68). The seam contains much shale and iron pyrites. Borings to depths of 254, 84, and 88 ft. failed to find coal (**S.** 92).

SHAPUR (22° 12′: 77° 58′). This field is situated in the valley of the Tawa R. between Betul and Hoshangabad. It has an exposed area of about 26 sq. miles. Thin seams of coal were noticed in the BHURA STREAM by Finnis (**584**—1;—2, 73) in 1831. About the year 1848, seams were discovered at SONADA (22° 16′: 77° 52′), and MARDANPUR (22° 14′: 78° 0′), the thickest measuring 20 ins. and 2 ft. 6 ins. respectively (Jacob, **923**—1, 185; Johnston, **949**). Samples of the coal tested at Bombay are said to have given good results (Impey, **905**—1, 15), and an attempt was made to transport a

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consignment from the Sonada seam in country boats down the Narbada to Broach; but nearly half the coal was lost on the voyage, and the experiment does not appear to have been repeated (Hamilton, **748**—2; Fenwick, **571**).

The outcrops were examined in 1863 by J. G. Medlicott (**1199**—3, 154), and again in 1868 by Blanford (**148**—18). Although numerous seams were found, the thickest measured only 4 ft., and in both cases the opinion expressed was distinctly unfavourable. A complete survey was made by H. B. Medlicott (**1197**—38) in 1875, and on his advice several borings were put down. None of these, however, succeeded in proving coal of better quality than that seen at the outcrop (**S.** 93).

Bilaspur.—KORBA (22° 21′: 82° 46′). This field is situated in the valley of the Hasdo R., and covers an area of more than 300 sq. miles. In 1870 Blanford (**148**—24) described an outcrop near Korba, exposing 50 ft. of coal of fair quality in a section measuring 89 ft.; and pointed out that it would be necessary to resort to boring in order to prove the value of the field, the coal measures being almost entirely concealed by alluvium. On analysis the bulk of the coal was found to contain over 30 per cent. of ash.

Another seam, 5 ft. 3 ins. thick, was afterwards found by Lala Hira Lal on the Aharan R. near SUMEDHA (22° 24′: 82° 42′), containing only 6·8 per cent. of ash (*see* King, **987**—35, 223). Borings were put down in 1887, but failed to prove the existence of any large quantity of good coal (King, **987**—38, 198).

Samples from a boring near the seam discovered by Lala Hira Lal gave the following average result on analysis:—C=53·21 : Vol. =28·08 : Water=5·30 : Ash=13·41 per cent. (**S.** 84).

Chanda.—The coal fields of the Chanda district extend along the valley of the Wardha R. for a distance of about 72 miles. The discovery of coal in this area is recorded by Malcolmson in 1834 (**1158**—6, 341) between the Baingang (Penganga), and Wardha rivers. The whole of the area was surveyed by Hughes (**888**—20) in 1877, when the following separate coal fields were described:—

BALLARPUR (19° 51′: 79° 24′). This field lies partly in the State of Hyderabad, west of the Wardha R. A seam of coal on that side, 6 ft. thick, was found by Blanford (**148**—19) in 1868. Borings put down on the British side of the river failed at that time to reach the thick seam, the thickest coal met with measuring only 3 ft. (Oldham, **1326**—55; —61; —64; —65; Fryar, **625**—3).

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Shortly before the abandonment of the Warora collieries (*see below*), the exploration was renewed by Government, and a seam with an average thickness of 40 ft. was proved over an area of 1½ sq. miles. Two shafts were at once sunk, and production began in 1906 with an output of 916 tons (**861**, 55). The average annual production during the five years 1909 to 1913 was 88,498 tons. In 1915 it amounted to 94,880 tons.

The seam being worked measures 8 ft. in thickness. Samples from the boring cores gave the following average result on analysis (2 samples):—C=45·34 : Vol.=31·09 : Water=12·30 : Ash=11·27 per cent. (**S.** 90):

BANDAR (20° 30′: 79° 21′). The area of the coal bearing (Barakar) rocks is about 6 sq. miles (Hughes, **888**—20, 145). No outcrops were seen, but seams with an aggregate thickness of 17 ft. were proved by borings over an area of one sq. mile. In quality the coal resembles that of Warora (**S.** 90).

CHANDA (19° 56′: 79° 22′). Several borings were put down in 1869-70 near the town of Chanda, but the thickest seam met with measured no more than 2 ft. None of the holes was carried to a greater depth than 250 ft.

GHUGHUS (19° 56′: 79° 10′). A seam varying in thickness from 2 to 5 ft. occurs on both sides of the Wardha R. at this locality (Blanford, **148**—19). Borings put down in 1869-70 proved the existence of a seam with an average thickness of 30 ft. (Oldham, **1326**—55, 97 ;—61, 46), and a colliery was shortly afterwards opened. A description of the workings has been given by Wragge (**1969**—2), who estimated the thickness of workable coal at 20 ft., and the quantity available at about 40 million tons.

According to Hughes (**888**—20, 32, 98), the productive area of the field is 3 sq. miles, and the estimated quantity available about 90 million tons. When in full working order the colliery produced about 70 tons monthly, but within a few years it was closed owing to the more advantageous position of the Warora mines.

Analyses of 32 samples from a boring near Ghughus gave the following average result :—C=45·61 : Vol.=33·49 : Ash=20·90 per cent. Trials of the coal on the Great Indian Peninsula Railway are described by Oldham (**1326**—55, 98) as having given fairly satisfactory results (**S.** 89).

TELWASA (20° 3′: 79° 8′ 30″). Borings at this locality passed through a seam 58 ft. 10 ins. thick at a depth of 64 ft. from the surface, including three beds of coal with an aggregate thickness of over 40 ft. (Oldham, **1326**—60, 2). The average composition of 42

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samples was :—C=43·94 : Vol.—33·15 : Ash=22·91 per cent. (Hughes, **888**—20, 31).

WARORA (20° 14′: 79° 4′). Coal was discovered by means of borings in 1870 and the following years. Two seams of 15 and 20 ft., including coal averaging 12 and 15 ft. thick respectively, were passed through and proved over an area of 420 acres (Ness, **1288**—1 ;—2). Collieries were opened in 1873 and worked for 33 years under considerable difficulties, owing to an abnormally heavy water discharge, and the liability of the coal to spontaneous combustion. A serious subsidence of the workings in 1906 led to the closing down of the collieries, and the removal of the plant to Ballarpur (Simpson, **1640**—7). Full details of the working of the mines have been given by Bunning (**231**) and Clarke (**323**, 187).

Hughes (**888**—20, 23) in 1877 estimated the area of the field at 3 sq. miles, and the total quantity of coal available at 20 million tons. The average annual output, during the five years immediately preceding the abandonment, was 132,953 tons. The total amount raised during the working of the colliery was about 3 million tons.

The coal is friable and inferior in quality to that of Raniganj, containing a high proportion of moisture and of sulphur in the form of pyrites. The average composition of 2 samples from the original borings was :—C=43·80 : Vol.=29·33 : Water—11·72 ; Sulphur=1·55 : Ash=13·60 per cent. (**S.** 88).

Chhindwara.—The Chhindwara coal fields are situated on the southern flanks of the Satpura range in the valleys of the Tawa, Kanhan, and Pench rivers, covering an area of about 100 sq. miles. Thin seams of coal were discovered in 1852 by Jerdon and Sankey (**1555**—1) at BARKOI (22° 11′: 78° 46′), and were mentioned in 1855 by Hislop (**842**—3, 556). The geology of the coal measures was described in 1867 by Sopwith (**1676**), who recognised three groups of strata :—

Upper,—Thick beds of sandstone with thin layers of shale and coal.

Middle,—Compact sandstones and shales with workable coal seams, 13, 14, and 12 ft. thick respectively.

Lower,—Green and grey shales, etc., with many thin seams of coal.

In 1866 the Pench valley area was examined by Blanford (**148**—13 ;—71), who has given details of eleven outcrops showing seams of good coal, varying from 3 to 12 ft. in thickness. Lastly, the

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whole area was surveyed by Jones (**952**—3) in 1887, when five separate fields were distinguished :—

BARKOI (22° 11′: 78° 46′), or PENCH VALLEY. Area 7·4 sq. miles. One seam of good coal at least occurs, with an average thickness of 5 ft. Quarries were opened in the outcrop about the year 1862; but owing to difficulties of transport the workings were abandoned, and no further development took place till 1905, when collieries were opened at Chandametta and Barkoi. The method of working the coal has been described by Ditmas (**488**). Three workable seams have been proved, measuring 9½, 5, and 5 ft. thick respectively. The quantity of coal available is stated to be not less than 100 million tons. The average annual output for the five years 1909 to 1913 was 84,686 tons. In 1915 the output amounted to 103,152 tons.

Analysis (average of 3 samples) :—C=53·5 : Vol.=22·8 : Ash=23·6 per cent.

HINGLADEVI (22° 10′: 78° 44′). Area 2·8 sq. miles. One seam, varying in thickness from 2 to 5 ft., is exposed. The coal is said to be of good quality.

KANHAN R. Area 12 sq. miles. Several seams from 5 to 10 ft. thick are exposed. A sample from an outcrop at DATLA (22° 11′ 30″: 78° 38′) yielded on analysis :—C=48·58 : Vol.=28·36 : Water=5·34 : Ash=17·72 per cent. Samples from other seams contained over 40 per cent. of ash.

SIRGORA (22° 12′: 78° 57′). Area 1·1 sq. miles. A seam found in sinking a well measured at least 5 ft. in thickness. Analysis :—C=61·6 : Vol.=28·0 : Ash=10·4 per cent.

TAWA R. (22° 14′: 78° 0′). This field lies partly in the Betul district, covering an area of about 79 sq. miles. Outcrops are not numerous, but seams measuring 7 to 11 ft. in thickness were found. Analysis (average of 2 samples):—C=51·90 : Vol.=26·20 : Water=3·05 : Ash=18·85 per cent. (**S.** 94).

Jhilmilli.—JHILMILLI (23° 24′: 82° 55′). This field has hitherto been only cursorily examined (Hughes, **888**—29, 205). The area is about 41 sq. miles. Outcrops of five seams were found along the MANIKMARA stream. The coal is of poor quality in all but one, of which only 16 ins. is exposed. A sample of this coal yielded on analysis :—C=60·6 : Vol.=33·8 : Ash=5·6 per cent. (**S.** 80).

Jubbulpore.—LAMETA GHAT (23° 6′: 79° 53′). A discovery of coal at this locality was reported by Spilsbury (**1684**—6) in 1839. According to Mallet (**1159**—52, 146) the seam is nearly 3 ft. thick, of which 2 ft. 3 ins. is coal. The quality is very poor, a picked

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sample yielding :—C=37·28 : Vol.=30·28 : Water=12·28 : Ash= 20·16 per cent. It was being quarried to supply brick-burning works at Jubbulpore. The beds in which the coal occurs are of upper Gondwana age (**S.** 87).

Korea.—In his memoir on the coal fields of S. Rewah, Hughes (**888**—29, 202, 204) briefly described two areas of Gondwana rocks to which the names KURASIA and KOREAGARH were given ; and at p. 196 *seq.* a number of outcrops in that portion of the great Sohagpur field which extends eastwards into the valley of the HASDO (HESTHO) R. in Korea State (**S.** 83).

The coal resources of the State have recently (1914) been investigated by Fermor (**577**—46, 171), who has distinguished four separate fields :—

JHAGRAKHAND (23° 11′: 82° 15′). A portion of the Sohagpur field, 22 sq. miles in area, projecting into the Korea State. A continuation of the Bhalmuri seam in that field was found in the Jhagrakhand and Neori streams, with a thickness of 5 ft. to 6 ft. 4 ins. The quality of the coal is said to be good (Hughes, **888**—29. 198).

KOREAGARH (23° 8′: 82° 32′). Area about 6 sq. miles. In the course of a hurried examination by Lala Hira Lal, four seams of a few inches thick were discovered (Hughes, **888**—29, 204). Three outcrops from 3 to 5 ft. in thickness have since been found (Fermor, **577**—46, 211).

KURASIA (23° 13′: 82° 27′). Area about 48 sq. miles. Two groups of outcrops were examined by Fermor (**577**—46, 195) :—

KURASIA GROUP.—Coal was found at six horizons. The principal seam, No. 4, ranges from a foot to 8 ft. 6 ins. in thickness, and probably extends over an area of 4 sq. miles. The estimated yield would be about 5½ million tons per sq. mile. Analysis (average of 6 samples) :—C=48·86 : Vol.=30·92 : Water=8·66 : Ash=11·56 per cent.

CHIRMIRI GROUP.—Seven seams of an aggregate thickness of 36 ft. were measured. Coal of an average thickness of 10 ft. possibly extends over an area of 2 sq. miles. The estimated yield would be about 11 million tons per sq. mile. Analysis (average of 10 samples): —C=51·2 : Vol.=29·1 : Water=7·7 : Ash=12·0 per cent.

SANHAT (23° 29′: 82° 35′). Area about 330 sq. miles. Two seams of workable value have been found. Of these the lower is worthless in the western half of the field, but thickens eastwards to between 4 and 9 ft. The upper seam thickens in the opposite direction, varying from 3 ft. 6 ins. to 9 ft. in the western portion of

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the field. Analyses—Lower seam (average of 3 samples):—C=44·80: Vol.=28·22: Water=5·79: Ash=21·19 per cent. Upper seam (average of 5 samples):—C=44·00: Vol.=24·00: Water=4·19: Ash=27·81 per cent.

Narsinghpur.—MOHPANI (22° 46′: 78° 54′). The discovery of a seam of coal, said to be 14 ft. thick, was reported by Ouseley in 1835 (**1349**—2). Descriptions of the outcrops of three seams were subsequently given by Jacob (**923**—2, 46, 140), J. G. Medlicott (**1199**—1), and Blackwell (**139**, 18), whose estimates of their thickness differed in some degree; but in his memoir on the central Narbada valley, J. G. Medlicott (**1199**—3, 169) gave a section showing four seams measuring 10, 2½, 5, and 4 ft. respectively.

In 1870 the structure of the field was described by H. B. Medlicott (**1197**—21). At that time mining operations had been in progress for about 8 years, and the aggregate thickness of coal was found to be about 25 ft. The area actually proved did not exceed one sq. mile. For many years repeated efforts were made to reach the coal outside this limit by means of borings, but met with little success (Medlicott, **1197**—51). The working of the colliery was always precarious, with the lower seams permanently on fire, and a heavy influx of water from above through fissures in the bed of the Sitariva R., beneath which the galleries of the mine were situated. In 1902 the colliery was abandoned. The total amount of coal won, since the colliery was opened in 1862, was 450,845 tons.

A fortunate discovery in 1892 by Messrs. F. L. G. Simpson, the manager of the colliery, and La Touche, of fossil plants in the outcrop of a band of sandstone which had hitherto been considered to lie below the coal horizon, situated about 2 miles to the west of Mohpani, led to the sinking of a borehole which passed through coal at no great depth from the surface (*see* King, **987**—49, 3). Further exploration has proved the existence of seams with an aggregate thickness of 27 ft. over a considerable area. This field is now being worked by the Great Indian Peninsula Railway Co., which purchased the undertaking from the Narbada Coal and Iron Co. in 1904. The average annual output for the five years 1909 to 1913 was 54,776 tons. In 1915 it amounted to 55,086 tons.

Recent analyses of the coal give the following average composition:—C=48·71: Vol.=24·26: Water=2·52: Sulphur=0·50: Ash=24·01 per cent. (**S.** 92).

Raigarh.—RAMPUR (21° 48′: 84° 0′). This coal field lies partly in the province of Bihar and Orissa, the town of Rampur, from

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which it takes its name, being situated in the district of Sambalpur. The existence of coal appears to have been first made known by Saxton (**1564**—1) in 1855, when he obtained specimens from a seam exposed on the IB R., which forms the eastern boundary of the field.

In 1871, and again in 1875, portions were described by Ball (**71**—13;—21) as the RAIGARH-HINGIR field. The western boundaries are ill defined, but the area is said to be about 400 sq. miles. Since the rocks are only slightly disturbed, outcrops are not numerous, and the seams that were observed consist mainly of carbonaceous shale with layers of coal seldom exceeding a few inches in thickness. Systematic exploration by means of borings was undertaken between the years 1884 and 1886, under the superintendence of Dr. King (**987**—30;—32, 196;—35), but the samples obtained gave a uniformly poor result on analysis, none of them containing less than 30 per cent. of ash. They were, in fact, less favourable than some of the specimens collected from the outcrop.

Interest in this field was revived in 1891, when a seam of coal of fair quality, 1 ft. thick, was passed through in sinking the foundations of the Ib river bridge on the Bengal-Nagpur Railway (King, **987**—46, 2). A fresh survey of the eastern portion of the field was then made by Reader (**1466**—1;—3). Four seams varying in thickness from 4 to 8 ft. were proved by boring; but with the exception of the Ib bridge seam, all contained more than 30 per cent. of ash. Further exploration was recommended in order to prove the extent of this seam, as well as the lowest beds of the Barakar group, which had not been tested by the borings.

A colliery was established here in 1909. The annual output has increased from 830 tons in the first year of working to 60,883 tons in 1914 and 58,825 tons in 1915. The average composition of 2 samples from the Ib bridge seam is:—C=53·6: Vol.=22·6: Water=8·5: Ash=15·3 per cent. (**S.** 85).

Sarguja.—BISRAMPUR (23° 7′: 83° 15′). Surveyed by Ball (**71**—15) in 1873. The coal measures are exposed over an area of about 400 sq. miles. Many outcrops of thin seams were described, and the field is said to contain a fair abundance of good coal, but borings are required to prove the extent and continuity of the seams. The following analyses are given:—

RER and PASANG RIVERS (2 samples):—C=57·0: Vol.=37·6: Ash=5·4 per cent.

MAHAN and MASAN RIVERS (3 samples):—C=48·1: Vol.=32·3: Ash=19·6 per cent. (**S.** 81).

LAKHANPUR (22° 59′: 83° 6′). Ball surveyed a portion of this field, 50 sq. miles in area, in 1882 (**71**—53), and found only one promising seam of coal, 5 ft. 6 ins. thick, at KUTKONA (23° 3′: 83° 6′) on the Chandnai R. According to Lala Hira Lal (MS. report, 1885-87), the total area is 340 sq. miles. Several outcrops of coal from 3 to 9 ft. thick were found. A sample from a seam 5 ft. 6 ins. thick on the Atem stream near PARSA (22° 51′: 82° 52′) yielded on analysis :— C=50·90 : Vol.=28·70 : Water=7·50 : Ash=12·90 per cent. (**S.** 81).

RAMKOLA-TATAPANI (23° 39′: 83° 3′)—(23° 41′: 83° 43′). A discovery of coal by Franklin at MANPUR (23° 43′: 83° 27′) on the Morne R. is recorded in 1830 (**616**—6, 218). The two fields, which lie within a few miles of each other, and are no doubt connected beneath a tract of upper Gondwana (Mahadeva) rocks, were surveyed in 1878-79 by Griesbach (**708**—1). The total area is about 800 sq. miles, but the exposed area of coal measures is about 100 sq. miles. Three groups of seams were met with, mostly confined to the middle of the Barakars, though few of them were of workable thickness and quality. The largest and best seam occurs on the MORNE R., where it is 7 ft. 9 ins. thick; but it thins out to the westward to 3 ft. 6 ins. The quantity of coal available was not estimated, nor have any analyses been made (**S.** 80).

RAMPUR (22° 35′: 83° 16′). A cursory examination made in 1882 by Ball (**71**—53, 110) revealed the existence of only one seam of rather stony coal, 4 ft. 6 ins. thick. Lala Hira Lal (MS. report, 1886-87) estimated the total area at 70 sq. miles, and found numerous outcrops varying from 2 to 7 ft. thick. One seam of 5 ft., exposed in a tributary of the Dhamgora R., is said to have contained less than 4 per cent. of ash (**S.** 83).

In addition to the fields mentioned above, the following have been described by Lala Hira Lal in unpublished MS. reports, 1885-89 :—

BANSAR (23° 7′: 83° 21′). Area about 10 sq. miles. One seam measuring 12 ins. was found.

DAMHAMUNDA (22° 56′ 30″: 82° 33′). Area 4½ sq. miles. Coal poor and seams thin.

PANCHBHAINI (23° 11′: 82° 55′). Area about 4½ sq. miles. Several seams of good quality occur, varying from 18 ins. to over 3 ft. in thickness.

SENDURGAR (22° 49′: 82° 26′). Area about 20 sq. miles. Seams of 10 ft. and 4 ft. occur, yielding respectively on analysis :—C=50·20 : Vol.=20·20 : Water=6·50 : Ash=23·10; and C=54·40 : Vol.=30·74 : Water=8·46 : Ash=6·40 per cent. (**S.** 81-83).

Udaipur.—MAND R. (22° 15′: 83° 15′). The existence of several seams, one of them 20 ft. thick, on the Mand R. was recorded by

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Blanford (**148**—25) in 1870, and others were described by Ball (**71**—53, 112) in 1882. In all of these coal of good quality occurred only ir thin layers. A number of boreholes put down under the superintendence of Dr. King (**987**—35, 222;—38) failed to detect the presence of coal containing less than 30 per cent. of ash. The area of the field is about 300 sq. miles (**S.** 85).

Yeotmal.—WUN (20° 3′: 79° 1′). This coal field belongs to the Wardha valley group, mentioned above under Chanda. In 1870, on the evidence of borings, Oldham (*see* Lyall, **1107**, 25) estimated the average workable thickness of coal at 20 ft., over an area of 40 sq. miles, giving a total quantity available of 480 million tons. Further exploration enabled Hughes (**888**—20, 38) to increase the estimate of the total quantity to 2,100 million tons, of which he considered that 255 million tons would be available within a depth of 500 ft. The probably productive coal area was found to be about 80 sq. miles.

An experimental shaft was sunk at PISGAON (20° 9′: 78° 53′) in 1873, and a certain amount of coal raised for trial; but operations were suspended on the opening of the Warora colliery. The average composition of 2 samples of this coal was:—C=64·0: Vol.=19·4: Ash=16·6 per cent. (**S.** 89).

HYDERABAD.

Adilabad.—AKSAPUR (19° 21′: 79° 28′). A small tract of Barakar rocks, exposed on the Jangaon R., was noted by King (**987**—23, 180). No coal has been found (**S.** 100).

ANTARGAON (19° 32′ 30″: 79° 33′). A seam 6 ft. thick, including 9 ins. of shale, was found by Hughes (**888**—20, 63) a *little* S. of LATHI GHAT on the Wardha. R. An outcrop of probably the same seam, 5 ft. thick, was found at KONDAI-KA-PAHAR. Analysis:—C=51·26: Vol.=28·25: Ash=20·49 pe rcent. (**S.** 100).

CHINUR (18° 52′: 79° 52′). In 1844 Newbold (**1294**—35) noted the occurrence of coal on the Pranhita R. at KOTA (18° 54′: 80° 2′). Borings were put down at the spot between the years 1852 and 1857 (Bell, **101**—1;—2; Wall, **1875**—1; Walker, **1874**; **1868**—6), and a seam 2 ft. 6 ins. thick was met with at a depth of 29 ft., but no useful coal was found.

Hughes in 1878 (**888**—22, 21) discovered that the coal measures occupy a narrow strip of country between Chinur and SANDRAPALI (18° 47′: 79° 56′). No outcrops of coal were detected, but large fragments were found in the bed of the Godavari near the mouth of the Sandrapali stream (**S.** 99).

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SASTI (19° 49′: 79° 23′). This field is a continuation, on the west side of the Wardha R., of the Ballarpur field in the Chanda district, Central Provinces. Large numbers of borings were put down between the years 1871 and 1874, and coal with an average thickness of 40 ft. was proved over an area of 1½ sq. mile. Hughes (**888**—20, 54, 99) estimated the total amount available at 30 million tons (**S.** 90,100).

TANDUR (19° 9′: 79° 30′). This village lies near the centre of a narrow belt of Barakar rocks extending from KHAIRGURA (19° 14′: 79° 26′) to AKSAPALI (19° 1′: 79° 35′). A seam of coal, 15 ft. thick at Khairgura, was traced by Hughes (**888**—22, 20) for a distance of 7 miles to the S. E., decreasing in thickness to 9 ft. A sample from KHAIRGURA yielded on analysis :—C=45·6 : Vol.=32·8 : Water=9·4 : Ash=12·2 per cent. (**S.** 100).

Warangal.—BANDALLA (18° 6′: 80° 20′). A description of an outcrop of coal, 6 ft. thick, discovered by Heenan on the KUMERSANI R., is quoted by King (**987**—23, 184). Ten years previously, in 1871, Blanford (**148**—29) had noted the occurrence of fragments of coal in the same river at ALAPALLI (17° 50′: 80° 32′), which may have been derived from an outcrop of this seam (**S.** 99).

KAMARAM (18° 15′: 80° 22′ 30″). Described by King (**987**—8, 50). The area is about 156 acres. Two seams of good coal occur, 6 ft. and 9 ft. thick respectively. The quantity available is estimated at about 1,130,000 tons (**S.** 99).

KUNNIGIRI (17° 21′: 80° 40′), or CHANDRAGUNDA. King (**987**—23, 194) mentions a small patch of Barakar rocks here. No coal was found (**S.** 96).

LINGALLA (18° 0′: 80° 54′). Blanford (**148**—28) records the discovery by Mr. Vanstavern of a coal seam, 5 ft. thick, in the bed of the Godavari at this locality, and of two thinner seams in the banks. On the British side of the river a seam of good coal, 5 ft. thick, was struck in an experimental pit at 11 ft. from the surface, and 70 tons of coal were raised (**S.** 97).

MADAVARAM (17° 28′ 30″: 81° 16). This field is traversed by the Godavari R., and covers an area of about 24 sq. miles. A portion was tested by borings in 1871 under Blanford's supervision (**148**—28, 60), when several thin seams were passed through. The quantity proved was not more than 25,000 tons. On the Hyderabad side of the river three seams, of which two measured 4 and 6 ft. respectively, were subsequently (1874) found by boring (King, **987**—23, 193).

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More recently (1891-95) a trial pit was sunk at RAJAHZOMPALLI, on the British side of the river, and a seam, 5 ft. 6 ins. thick, of good coal was struck. About 3,500 tons of coal were taken out, but the enterprise was then abandoned (**S.** 96).

SINGARENI (17° 31′: 80° 19′ 30″). In 1872 the outcrop of a seam of coal, of which not more than 2 ft. was exposed, was discovered by King (**987**—9; —28) in the bed of the YELLINDALLAPAD STREAM, about 7 miles to the N. E. of Singareni. The area covered by Barakar rocks in the neighbourhood was found to be about 9 sq. miles. Subsequent exploration by means of borings revealed the existence of four seams, measuring from above downwards 30 to 40 ft., 6 ft. 6 ins., 4 ft. 6 ins. and 3 ft. 9 ins. to 7 ft. in thickness respectively. Only the lowest of these, known as the King seam, has hitherto been worked.

Various estimates have been made of the amount of coal contained in this seam, the latest (1894) by Saise (**1545**—2) giving it as 36 million tons. Some part of the upper, or thick seam, is also said to be workable.

The average annual output of the colliery which was opened in 1886, during the five years 1909 to 1913, was 497,646 tons. In 1915 it amounted to 586,824 tons. Full details of the working of the colliery have been given by Kirkup (**991**—1).

The following analyses of the coal have been made:—

Thick seam:—C=52·5: Vol.=34·5: Ash=13·0 per cent.

King seam:—C=56·50: Vol.=25·25: Water=7·60: Ash=10·65 per cent. (**S.** 97).

KASHMIR.

Jammu.—The coal bearing rocks of this district are exposed along the flanks of a series of detached dome-shaped folds whose crests have been removed by denudation, and thus occupy a number of elliptical areas, or inliers, surrounded on all sides by higher beds. The coal seams are associated with nummulitic limestones and are of lower Tertiary age. In all cases they have been subjected to great disturbance, and the coal is consequently in a crushed and friable condition. The following areas have been described:—

DANDLI (33° 32′: 74° 2′). The occurrence of coal on the Pench R. at this locality was reported by Medlicott (**1197**—15, 122) in 1868. A number of outcrops were examined by Wright (**1972**—2) in 1906. Two main seams occur, but are very irregular, and seldom exceed a few inches in thickness. The quality of the coal is poor.

KALAKOT (33° 14′: 74° 27). Coal is found in a continuous seam surrounding an inlier of limestone about 4 miles in length. Some

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of the coal is of fair quality, but it never remains constant in thickness for more than a few feet of outcrop. Omitting coal with more than 30 per cent. of ash, the average composition of 5 samples was:—C=70·15: Vol.=11·55: Water=2·72: Ash=15·58 per cent. (Simpson, **1640**—3, 220).

Ladda (33° 1′: 75° 6′). This field was thoroughly prospected in 1902-03, when the question of utilising the coal in connection with proposed railway extension in Kashmir was discussed (Simpson, **1640**—3). The thickness of the single seam exposed varies greatly, but it was considered that portions of it, with an average thickness of 2 ft. 7 ins., might be worked over a length of outcrop of about 6 miles at the eastern end of the field. A provisional estimate by Simpson (*l. c.*, 246) showed that the probable amount of coal available might be $1\frac{3}{4}$ million tons, and that in addition about 2 million tons might prove to be workable.

Numerous analyses of the coal were made, but in the majority of the samples the proportion of ash was well over 30 per cent. The average composition of 6 samples containing less than this percentage of ash was:—C=69·74: Vol.=12·42: Water=1·03: Ash=16·81 per cent. The proportion of sulphur is high, amounting in some cases to over 5 per cent.

Lodhra (33° 10′: 75° 9′). In this area, lying about 10 miles to the N. of the Ladda field, nothing but carbonaceous shale was found, containing in most cases more than 40 per cent. of ash.

Mehowgala (33° 13′: 74° 33′). Coal occurs at two horizons separated by about 20 ft. of shale. The upper seam does not exceed 2 ft. in thickness; while in the lower seam the coal occurs in lenticular beds of no great extent (La Touche, **1034**—9, 68). The average composition of 6 samples collected by Simpson in the course of prospecting operations (**1640**—3, 216) was:—C=71·60: Vol.=14·76: Water=3·78: Ash=9·86 per cent.

Sangar Marg (33° 12′: 74° 41′). This field lies at the western extremity of the Ladda inlier, and is connected with that coal field across the deep valley of the Chenab, which cuts through the centre of the inlier, by a continuous band of the coal measure rocks, exposed along the northern flanks of the elevated zone (Simpson, **1640**—3, 210). The coal measures are twice brought to the surface by undulations of the strata, so that a greater length of outcrop than usual is exposed. Occasionally two seams are present, but only the lower is of importance, and the thickness of this seldom remains constant for more than a few feet (La Touche, **1034**—9). It sometimes reaches a thickness of 7 ft. 6 ins., but is more usually about 2 ft. The majority of the samples collected by Simpson in

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the course of prospecting operations contained more than 30 per cent. of ash. The average composition of the 3 best samples was :—C=77·37 : Vol.=13·33 : Water=1·24 : Ash=8·06 per cent. One of these samples contained 4·29 per cent. of sulphur.

SIRO VALLEY (33° 12′: 74° 32′). This is a small elliptical inlier situated about a mile to the W. of the Mehowgala field. The thickness of the seam appears to be rather more constant than usual. Assuming a thickness of 2 ft. over a length of outcrop of 6 miles, Simpson (**1640**—3, 250) estimated the quantity that might be extracted at about 750,000 tons. Only one of the samples analysed contained as much as 40 per cent. of ash. The average composition of the remaining 6 samples was :—C=66·84 : Vol.=11·61 : Water=1·19 : Ash=20·36 per cent. (**S.** 100).

MADRAS.

Godavari.—BEDDADANOL (17° 14′ 30″: 81° 17′). The existence of a small area of Barakar rocks here was noted by Blanford during a survey of the lower Godavari valley in 1871 (**148**—30, 24). In the following year, and again in 1873, it was examined by King (**987**—10 ;—11), who found that the exposed area was about 5¼ sq. miles. No coal seams were visible at the surface, but a number of borings subsequently put down passed through four seams of coal and carbonaceous shale, one of which was 4 ft. 6 ins. thick (King, **987**—12, 159 ;—14 ;—23, 179 ;—27). The quality of the coal was exceedingly poor, an average sample containing :—C=16·4 : Vol.=30·6 : Ash=53 per cent.; while picked fragments yielded :—C=37·0 : Vol.=37·8 : Ash=25·2 per cent. (**S.** 107).

DAMERCHERLA (17° 36′: 81° 8′) and LINGALLA (18° 0′: 80° 54′). *See* **HYDERABAD-Warangal-MADAVARAM.**

Reported discoveries of coal in other parts of Madras and southern India have recently been discussed by Simpson (**1640**—10, 102-106). With the possible exception of certain beds noticed below under the heading **LIGNITE,** none of these occurrences is of any economic value.

NORTH-WEST FRONTIER PROVINCE.

Hazara.—DORE R. (34° 9′: 73° 22′). Outcrops of coaly shale beneath nummulitic limestone, near the point where the road from Murree to Abbotabad crosses the Dore R., were noticed by Wynne (**1975**—25, 210) in 1879. According to Middlemiss (**1219**—13 ;—17, 287), the coal occurs along the axis of a compressed and dislocated overfold, and has been so sheared and crushed that its continuity cannot be depended upon. It varies greatly in thickness, reaching

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17 ft. in one place. The quality is very poor, average samples containing over 40 per cent. of ash. About 250 tons have been extracted and used for lime and brick burning in Abbotabad (**S.** 112).

Kohat.—Burnes (**235**—7) in 1833 reported the discovery of a bed of carbonaceous shale near KOHAT (33° 35′: 71° 30′). Specimens when analysed were found to contain only 6·2 per cent. of fixed carbon, and5 6·8 per cent. of ash.

Wynne (**1975**—15, 294) mentions the discovery by a native officer of coal at a locality which may be either DHAND (33° 14′: 71° 26′) or SHIN DHAND (33° 33′: 71° 41′). From its description and mode of occurrence he considered that it might be lignite, derived either from a pocket in upper-Tertiary sandstones, or from a layer in the alum shale zone.

Sherani Hills.—Reports of the occurrence of coal near MOGHAL KOT (31° 28′: 70° 9′) were found by La Touche (**1034**—20, 95) to refer merely to thin strings of carbonaceous matter in lower Tertiary beds (**S.** 108).

Waziristan.—Agha Abbas (**15**, 588) mentions an occurrence of coal beyond the PIR KARAL, a hill to the N. W. of KANIGURAM (32° 31′: 69° 51′).

PUNJAB.

Attock.—CHOI (33° 44′: 72° 16′ 30″). A lenticular bed of bright coal, occurring in the nummulitic limestone of the Chita range S. of Attock, was noted by Wynne (**1975**—17, 114) in 1877. Several borings and trial pits sunk by Scott (**1600**) in 1884 showed that no continuous seam of coal exists, and that the quality is poor (**S.** 112).

Jhelum (Salt Range).—The earliest connected accounts of the coal deposits of the Punjab Salt Range were published between the years 1848 and 1853 by Fleming (**591**—1, 509;—3, 661;—5, 340), who described the mode of occurrence and the distribution and quality of the coal at nine localities. This list was supplemented in 1868 by one drawn up by Dr. Oldham (**1326**—49), in which thirteen localities are mentioned. At several of these places,—KHEWRA, NILA, KARULI, NURPUR, DEHIWAL, CHAMIL, and SANGLIWAN, the coal was so thin and poor in quality that it was considered to be useless; while at SAWAKHAN, KATHA, and AMB it occurred in slipped masses of no great extent.

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The coal occurs at a single horizon in a band of shales and sandstone underlying the scarp of nummulitic (Eocene) limestone which extends along the crest of the range from east to west. It does not form a continuous seam, but is found in lenticular beds separated by wide intervals of barren ground (Wynne, **1975**—18, 105, 293). Mining in all cases is carried on by means of adits or inclines driven from the outcrop. The following areas have been worked :—

BHAGANWALA (32° 43′: 73° 19′ 30″). The coal seam here can be traced for about a mile along the scarp, and indications of its presence have been found over an area of about 7 sq. miles. In places it reaches a thickness of 5 or 7 ft., but for considerable lengths of outcrop it may disappear entirely. As a result of prospecting operations in 1893, La Touche (**1034**—22), estimated that the existence of about 88,000 tons of coal might be taken as proved, and that the total quantity available might amount to nearly a million tons. The coal had then been mined by local contractors since 1877, and about 2,000 tons had been extracted. In 1893 the North-Western Railway Company took over the mines, but abandoned them seven years later owing to deterioration in the quality of the coal. The maximum output was 13,145 tons in 1897 (**S.** 109).

A sample of the coal from the outcrop, collected by Fleming, yielded on analysis :—C=41·36 : Vol.=40·64 : Ash=18·00 per cent.

DANDOT (32° 39′: 73° 1′). The seam exposed here was considered by Fleming to be "of no importance," but it is nevertheless the only locality in the Salt Range where exploitation on a large scale has been found practicable. Mining has been carried on for many years. About 1,900 tons are said to have been raised here and at PIDH (*see below*) between the years 1863 and 1867 (Wynne, **1975**—18, 294). The mines were worked by the North-Western Railway Company from 1884 to 1912, when they were handed over to local contractors. The working of the colliery had always been attended with much difficulty, owing to the unstable character of the shales forming the roof and floor of the seam, and the liability of the coal to spontaneous combustion. The average thickness of the seam is not more than 2 ft. A description of the method of working the colliery was given by Clarke (**323**) in 1901.

In 1887 R. D. Oldham (MS. Report) estimated the area of the field at 2 sq. miles, and the quantity of coal available at about 2 million tons. An attempt to discover whether coal of a workable thickness extends beneath the plateau to the north of the colliery met with no success, though the horizon of the coal seam was reached in two borings (Hayden, **793**—26, 73). The combined output of the Dandot and Pidh collieries reached a maximum of 81,218 tons in

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1899, but during the five years preceding the closing of the mines the annual average fell to 45,386 tons.

The following analysis of the coal has been made :—C=47·17 : Vol.=36·81 : Water=6·13 ; Ash=9·89 per cent. (**S.** 110).

PIDH (32° 41′: 73° 2′). The coal here is about 3 ft. thick at the outcrop, and the seam dips at a high angle to the north (Oldham, **1326**—49). Mining was carried on by the North-Western Railway Company for the same period as at Dandot, and under similar conditions.

During the three years that the mines have been under native management, the average annual output of coal from the Jhelum district has amounted to 47,878 tons.

Mianwali.—ISA KHEL (32° 41′: 71° 20′). Specimens of coal collected by Burnes (**235**—17, 112) near KALABAGH, and forwarded to Calcutta, were pronounced by Prinsep (**1436**—32) to be of excellent quality. Jameson, however, who examined the deposits in 1842 (**931**—2 ;—3, 207) gave a very unfavourable report on their extent and quality. The coal then, and for some years afterwards, was being used to a certain extent on the Indus Flotilla steamers (Fleming, **591**—1, 516 ;—5, 272 ; and Verchère, **1839**—1, 44).

The field was visited in 1864 by Oldham (**1326**—49), who recognised that two distinct carbonaceous horizons are exposed, the lower of Jurassic, and the upper of Tertiary age. He thought that about 1,600 tons of fuel might be obtained from the Jurassic deposits near KALABAGH, but condemned the remaining seams examined as worthless, an opinion afterwards endorsed by Wynne (**1975**—28, 305).

In 1904 a detailed survey of the ground was made by Simpson **1640**—4). Three separate areas were distinguished :—

KALABAGH (32° 58′: 71° 37′). Jurassic. Bright jetty coal occurs in discontinuous layers at three horizons over a length of outcrop of 750 ft. About 16,500 tons might be obtained above free drainage level. Analysis of a representative sample gave :—C=42·29 : Vol. =24·16 : Water=4·04 : Sulphur=4·39 : Ash=25·12 per cent.

KUCH (33° 1′: 71° 35′). Jurassic. Two seams, 16 and 12 ins. thick respectively, are exposed over a length of outcrop of about 500 ft. About 14,000 tons of fuel might be obtained here. Analysis : —C=46·12 : Vol.=22·74 : Water=10·19 : Sulphur=2·35 : Ash= 18·60 per cent.

MALLA KHEL (32° 56′: 71° 13′ 30″). Tertiary. A seam with an average thickness of 2 ft. 3 ins. was traced for a distance of 6½ miles along the flanks of the Maidan range. The quantity that might be

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extracted above free drainage level was estimated at about 493,000 tons. The average composition of 21 samples was :—C=40·0 : Vol. =37·0 : Water=9·0 : Sulphur=4·0 : Ash=10·0 per cent. (**S.** 111).

During the years 1907 to 1912 this field produced 7,518 tons of coal. In 1915 the output was 2,029 tons.

Shahpur (Salt Range).—JHAKAR KOT (32° 34′: 72° 28′) and TEJUWALA (32° 36′: 72° 30′). The coal occurs under the same conditions as at Dandot, etc., in the Jhelum district. The average thickness of the seam is about 3 ft., but it varies considerably within short distances. The mines are worked by local contractors, and the output is subject to large fluctuations. In 1906 it was 15,671 tons; but the average amount raised annually during the five years 1909 to 1913 was not more than 2,650 tons. The output in 1915 was 4,269 tons.

The following analyses have been made :—JHAKAR KOT. C= 46·50 : Vol.=35·66 : Water=7·60 : Ash=10·24 per cent. TEJUWALA. C=37·31 : Vol.=31·01 : Water=5·08 : Ash=26·60 per cent. (**861**, 70).

RAJPUTANA.

The existence of a glacial boulder bed at BAP (27° 22′: 72° 25′) in Jodhpur territory, recognised by R. D. Oldham as of Talcher age, and of upper Gondwana rocks further to the west in Jaisalmer, has suggested the possibility that the coal-bearing Damudas might be concealed beneath the sands of the Indian desert in the intervening area. The question was fully discussed after an examination of the ground by Oldham (**1324**—16 ;—25), who came to the conclusion that the prospects of finding workable coal are exceedingly small. A spot 3 miles to the S. of DEVIKOT (26° 40′: 71° 13′) was indicated as the best site for an experimental boring, but the trial has not yet been made. The only coal yet found in Rajputana is of lower Tertiary age.

Bikaner.—PALANA (27° 51′: 73° 19′). A seam of coal, 4 to 8 ft. thick, was discovered during the sinking of a well, at a depth of 212 ft. from the surface, beneath a band of nummulitic limestone (La Touche, **1034**—24). The seam, on being opened out, was found to be persistent over a considerable area, though the thickness varied from 3 to 30 ft., and a colliery was established in 1898. The method of working has been described by Clarke (**323**, 188). The output reached a maximum of 45,078 tons in 1904, but since then it has declined, the average amount raised annually during the five years

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1909 to 1913 being 15,197 tons. In 1915 the output was 17,796 tons.

The coal is dark brown in colour, with a woody texture, and becomes very friable on exposure to the air. The large percentage of moisture contained in it can be considerably reduced by a special process of briquetting, which has been described by Phillips (**1401**). The composition of the raw coal and briquettes is indicated by the following analyses :—

Coal :—C=38·16 : Vol.=35·36 : Water=22·90 : Ash=3·58 per cent.

Briquettes (average of 2 samples) :—C=38·79 : Vol.=42·50 : Water=12·08 : Ash=6·63 per cent. (**S.** 112).

SIKKIM.

Seams of coal reported as occurring in the valley of the GREAT RANGIT R. proved on examination to consist of dense black carbonaceous shales, having the appearance of bright coal, but unable to support combustion. The seams occur among slates of far greater age than the Indian coal measures (La Touche, **1034**—39, 95).

UNITED PROVINCES, *see under* **LIGNITE.**

COBALT.

BIHAR AND ORISSA.

Kalahandi.—A specimen of manganiferous iron ore collected at OLATURA (20° 20′: 83° 36′) by Walker (**1872**—3, 20) yielded on assay 0·82 per cent. of cobalt oxide.

BURMA.

Tavoy.—Theobald (**1763**—19, 95) states that he procured a nodule of earthy cobalt associated with manganese, imbedded in white clay, near HENZAI (HEINZÉ 14° 29′: 98° 12′). The specimen was not more than an ounce in weight (**B.** 325).

MADRAS.

Travancore.—Indications of the presence of cobalt have been detected in the sulphide ores occurring near ARUMANALLUR (8° 19′: 77° 28′), described by Masillamani (**298**, 13). A surface sample yielded 0·08 per cent. of cobalt on assay (**862**, 281).

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NEPAL.

A specimen of cobaltiferous matte, said to have been procured at the copper mines of KACHIPATAR ARGAH, Zilla Sowrobhar, situated 80 miles to the N. of DULHA (27° 23′: 83° 16′) in the Basti district, was described by Jones (**952**—7) in 1889. It contained 13·97 per cent. of cobalt. A specimen previously assayed by Mallet contained 11 per cent. of the metal (**B.** 325).

RAJPUTANA.

Jaipur.—KHETRI (28° 0′: 75° 51′). An ore of cobalt, locally known as *sehta*, has long been known to occur at the copper mines of BABAI and BAGOR in the neighbourhood of Khetri (A. E., **524**—2). Specimens were described by Middleton (**1221**—1) as a sulphide of cobalt, to which the name 'Syepoorite' (Jaipurite) was given by Nicol; and by Ross (**1513**—2) as a sulph-antimonial arsenide of cobalt. But Mallet (**1159**—24) has shown that the ore consists of a mixture of two minerals,—cobaltite, a sulphide of arsenic and cobalt, and a cobaltiferous variety of danaite. The cobaltite was found to contain 28·30 per cent. of cobalt.

According to Brooke (**203**—2, 524), the ore occurs in thin layers between the masses of copper pyrites. Not more than 200 lb. a month was produced at either of the mines. Hacket (**730**—4, 248) and Heron (*see* Hayden, **793**—31, 19) describe the *sehta* as occurring in minute crystals sparsely disseminated through the slates which contain the copper pyrites. The extraction of the ore, which was used mainly by the Jaipur enamellers, was discontinued about the year 1908 (**B.** 324).

COLUMBITE *see under* **RARE MINERALS.**

COPPER.

The copper industry in India generally is dealt with in the following papers:—

1901. Evans (**555**—9, 155). A brief history of the attempts that have been made to mine copper ores in India.

1907. Holland (**859**—64, 27). An account of the recent trend of the copper market, with reference to a possible revival of the Indian copper industry.

AFGHANISTAN.

In 1841 Drummond (**504**—2) gave details of a number of ancient copper workings situated in the neighbourhood of the Safed Koh,

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between Kabul and Kurram. The most promising veins were said to occur at DHERBAND and in the DOBANDI VALLEY (33° 50′: 69° 17′). The ore consists of bornite, chalcocite, and cuprite, containing respectively 60, 80, and 90 per cent. of metal. According to Griesbach (**708**—21, 79), the veins are developed along the contact of intrusive igneous rocks with shales and sandstones. A specimen of copper ore from KARATIZA HILL (33° 57′: 69° 27′) in the same neighbourhood was exhibited by Medlicott (**1197**—56, 4) in 1880. It contained 20 per cent. of copper.

Griesbach (*l.c.*, 77) also mentions the occurrence of traces of carbonate of copper on the south side of the KOTAL-I-MAULANA in KHARWAR (33° 40′: 68° 55′), at the contact of granite with metamorphic rocks (**B.** 265).

Vigne (**1846**—3, 142) has described a copper mine at SHIBAR, a day's march beyond Saiab, on the road from Ghazni to Kabul. The ore occurs in a quartz vein in slate.

Rich veins of copper ore are said to exist in the SHAH MAKSUD RANGE (31° 53′: 65° 20′), and to have been worked by Nadir Shah and the Sirdars of Kandahar (Hutton, **900**—8, 597). Very large profits are said to have been made (**B.** 265).

ANDAMAN ISLANDS.

RANG-U-CHANG (11° 34′: 92° 43′). Small quantities of copper pyrites were obtained by Mallet (**1159**—42, 80) in veins of hematite traversing eruptive rocks on the coast, several miles to the S. of Port Blair. A sample contained only 0·10 per cent. of metallic copper.

ASSAM.

Abor Hills.—SISI R. (28° 48′: 94° 56′). Rolled pebbles containing particles of chalcopyrite were noticed in the bed of the river by Brown (**211**—5, 253). It is remarked that the watershed might be worth the attention of prospectors.

Bor Kamti.—The Kamtis, inhabiting the hill region to the east of Upper Assam, are well known to be skilled workers in metal. While in their country, Maclaren (**1134**—2, 184) was shown specimens of chalcopyrite, probably derived from veins in serpentinous rocks.

Manipur.—Oldham (**1324**—3, 241) mentions that copper is worked in the south-eastern corner of the district. The ore is said to come from the hills bordering the KUBO VALLEY (**B.** 278).

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BALUCHISTAN.

Kharan.—Chrysocolla (silicate of copper) is widely disseminated in grains of varying size through syenite of Tertiary age in the RAS KOH (28° 49′: 65° 14′), and at several other places further west. At ROBAT (29° 32′: 63° 35′) large heaps of copper slag were seen. Copper ore also occurs at SAINDAK (29° 16′: 61° 33′) in veins as the result of solfataric action due to the intrusion of basaltic dykes (Vredenburg, **1854**—1, 291).

Las Bela.—A circumstantial account, derived from a native inhabitant of Karachi, has been given by de la Hoste (**456**—2) of the occurrence of copper ore at a locality 24 miles to the southward of Bela, identified by Griesbach (**708**—4, 57) as SHAH BELIAWL (25° 45′: 67° 0′). The ore on being smelted is said to have yielded 50 per cent. of metal (**B.** 264).

Quetta-Pishin.—Both Hutton (**900**—8, 581) and Griesbach (**708**—4, 57) mention the occurrence of poor ores of copper associated with white quartz in the KOJAK-AMRAN RANGE (**B.** 265).

Sarawan.—Concretions of malachite and azurite, in some cases with a core of copper glance, were found by Vredenburg (**1854**—36, 210) in the talus of Eocene coal measures between ZIARAT and JOHAN (29° 20′: 67° 0′).

BENGAL.

Darjeeling.—Campbell (**269**) announced the discovery in 1854 of copper ore at PASHOK (*see below*), about 20 miles from Darjeeling on the road to Kalimpong. In 1874 Mallet (**1159**—6, 69) examined all the known occurrences of the ore, and described the character of the deposits and the native methods of working them. The latter have also been described by H. F. Blanford (**147**—7).

The ores are of low grade, and consist of copper pyrites, generally associated with iron pyrites, disseminated through the slates and schists of the Daling series. They do not occur in true lodes. Their treatment consists in four processes:—(1) The ore is thoroughly pounded and washed. (2) It is smelted with charcoal in a primitive furnace, so as to form a regulus, the slag being removed at intervals by cooling the surface of the molten mass with a wisp of wet straw. (3) The regulus is pounded and mixed with cowdung, made into balls, and roasted with free access of air. (4) The roasted powder is re-smelted in the original furnace (**B.** 274).

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The localities that have been examined are :—

CHEL R. (26° 58′: 88° 46′). Seam exposed in bed of river. Said to be 4 ins. to a foot in width, and to consist of solid ore.

KALIMPONG (27° 4′: 88° 33′). The mine is situated about 2 miles to the N. E. of the station. The ore occurs in small irregular seams of quartz, and bands of very hard quartzite. The proportion of ore is very small. Abandoned on account of the hardness of the rock.

KOMAI (27° 1′: 88° 51′). Not mentioned by Mallet. The copper-bearing band is exposed on the left bank of the Mo Chu. According to Hayden (**793**—10), the ore is distributed in fairly large masses, in bands from 2 to 4 ft. in thickness, through slates. A sample from a prospecting drift yielded on assay 3·5 per cent. Cu and 1 dwt. 8 grs. of gold per ton. A picked sample gave 26 per cent. Cu.

MAHANADI (26° 52′: 88° 25′). At an old mine here the ore occurs in hornblende schist with quartz- and chlorite-schist, in little strings and clustered particles. Width about 2 ft.

MANGPHU (26° 58′: 88° 28′). This mine, situated on the left bank of the Teesta R., was the only one being worked at the time of Mallet's visit. The ore occurs in lenticular layers, up to a foot thick, in a band of clay slate about 3 ft. thick. Traces of ore were found throughout a total thickness of about 200 ft. of strata. The average yield is said to be about 4 per cent. The output for a year is said to have been about 5,760 lb. of metal.

MANGWA (27° 3′: 88° 28′). Specimens of iron pyrites examined by Piddington (**1405**—63, 479) contained traces of copper. Similar traces were found in specimens of hornblende rock from PANKABARI (26° 50′: 88° 20′).

PASHOK (27° 4′: 88° 27′ 30″). The ore occurs in quartzose hornblendic-schist, and is very sparsely disseminated. Attempts to work the deposit between the years 1854 and 1870 proved unsuccessful. On assay by Piddington (**1405**—63;—70) the rock in bulk yielded only 1·357 per cent. Cu. Copper ore is also said to have been found near the head of the Rangbong stream, W. of Pashok.

RANI HAT (26° 51′: 88° 21′). Copper ore occurs at two places. (1) In the bank of the RANI STREAM, about a mile above Rani Hat, iron pyrites with traces of copper is disseminated through quartz- and hornblende-schist. (2) Near the head of the CHOCHI STREAM 1,100 ft. above and a mile N. of Rani Hat, copper ore has been worked rather extensively. The ore stratum averages about 18 ins. in thickness, and has been proved to a distance of over 90 ft. along the dip.

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Re Ung (27° 0′: 88° 33′). A trial drift here showed clay slate with interbanded layers of quartzite containing small quantities of copper pyrites.

Sampthar (26° 58′: 88° 34′). Thin lenticular layers of quartz, containing copper and iron pyrites, have been exposed by a landslip in a ravine joining the Lisu to the S. of the village.

Yongri Hill (26° 57′: 88° 34′). Described by Mallet (**1159**—31) in 1882, when the mine had recently been opened. It is situated on the west slope of the hill at an elevation of about 2,500 ft. The cupriferous seam was 7 to 8 ins. thick, but occasionally thinned to 1 or 2 ins. The ore occurred in quartzose layers interbanded with clay slate, and contained a considerable proportion of iron pyrites. A sample on assay yielded 1·5 per cent. Cu, and a picked specimen 6·6 per cent.

Jalpaiguri.—Baxa (26° 45′: 89° 38′). Copper pyrites has been found, but not worked, at a spot on the hillside half a mile to the W. of Baxa (Mallet, **1159**—6, 79). The ore occurs with iron pyrites in quartzose layers in a greenishs late.

BHUTAN.

Chamurchi (26° 54′: 89° 11′). Copper ore is said to have been found near this place, but the locality has not been visited (Mallet, **1159**—6, 79).

BIHAR AND ORISSA.

A summary of information relative to the existence of copper ores in Chota Nagpur, compiled from various sources, was published by King and Pope (**989**, 95) in 1891.

Hazaribagh.—Baragunda (24° 5′ : 86° 7′). Accounts of extensive ancient copper workings at this locality have been given by McClelland (**1117**—33, 23) and Smith (**1655**—2, 97). The excavations extend for about three quarters of a mile, with an average width of 25 or 30 yds., along a low ridge composed of quartzite associated with gneiss, garnetiferous mica and talc schist, and hornblende schist. Copper pyrites, with galena and zinc blende, is found disseminated in small lenticular nodules through the schists, or penetrating veins of pellucid quartz. Picked specimens assayed by Piddington (**1405**—55) yielded 34·10 Cu: 33·98 Fe: and 31·42 S per cent. A carefully selected average sample assayed by Mallet (**1159**—50, 24) yielded 3·04 per cent. Cu. (**B.** 254).

In a more recent account (1895), Oates (**1315,** 439) states that the deposits consist of strings and bunches of copper pyrites permeat-

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ing garnetiferous mica schists. The thickness of the cupriferous band varies from 7 to 22 feet. Assays of average samples of the ore yielded from 1 to 1·5 per cent. Cu.

Several attempts have been made within the last 60 years to reopen the old workings, but have hitherto been attended with no permanent success. King (**987**—43, 250) records that in 1888 the Bengal Baragunda Copper Co. turned out 218 tons of refined copper.

GULGO (24° 24′ : 86° 25′ 30″). Mallet (**1159**—7, 34) mentions the occurrence of minute particles of copper pyrites with galena in a rock consisting of a mixture of garnet and coccolite, exposed in the bed of the Patru stream, to the N. E. of the village.

Manbhum.—Ball (**71**—8, 76) has recorded the discovery of ancient excavations in search of copper at PURDA (22° 59′ : 86° 39′) and KALIANPUR (23° 2′ : 86° 7′). The only signs left of the presence of the ore were incrustations of the carbonates of copper on the schist and quartz debris (**B.** 246).

Palamau.—Some traces of copper ore were found in sinking a well at DALTONGANJ (24° 2′ : 84° 7′), disseminated in beds of schistose gneiss (Ball, **71**—32, 125 ; **B.** 256).

Santal Parganas.—BAIRUKI (24° 35′ : 86° 40′). A report on specimens of copper ore from this locality, which is close to the East Indian railway, was drawn up by Piddington (**1405**—41), in 1851. The ore forms a red or liver-coloured mass, consisting of a mixture of cuprite, chalcopyrite, and tetrahedrite, with green carbonate of copper and galena. On assay the ores yielded from 20 to 40 per cent. Cu, and several of the samples contained traces of silver.

Excavations made by Sherwill (**1625**—15, 34) showed that the ore occurs in narrow veins running east and west along the strike of hornblendic schists and gneiss, also permeating the latter. Small strings of galena traverse the ore bodies from north to south. The deposit was traced for a distance of 100 feet (**B.** 244).

According to Mallet (**1159**—50, 25), the ore occurs in a discontinuous band of tremolite schist, varying in width from a few inches to 6 or 8 ft., enclosed in gneiss which is highly garnetiferous in places. The veins had been followed to a depth of over 150 ft. The ores were copper pyrites and purple copper, forming small lenticular masses parallel to the foliation of the schist, the former predominating in the lower part of the mine. Only a few tons were extracted, and the ore-bearing stratum is said to be very poor.

BODH BANDH (24° 0′ : 86° 55′). A discovery of copper pyrites in the bed of the Ajai R., to the N. E. of the village, is mentioned

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by Sherwill (**1625**—15, 10, 40). The ore is said to be of poor quality (**B.** 244).

Singhbhum.—The first allusion to the existence of copper ores in Singhbhum was made by Jones (**956**—1, 170) in 1829; but the remains of ancient excavations, which have been traced at frequent intervals for a distance of more than 80 miles, along a belt of country reaching from the Bamini R. near DUARPARAM (22° 45′ 30″ : 85° 38′) through Kharsawan, Seraikela, and Dhalbhum to BHAIRAGORA (22° 16′ 30″ : 86° 46′ 30″) on the borders of Mayurbhanj, as well as numerous heaps of slag, bear witness to the fact that the deposits had long been known and exploited. This ancient mining industry has been attributed by Ball (**71**—5) to the Seraks, or lay Jains, who may perhaps have discovered the ores some 2,000 years ago.

Several accounts of the deposits, and of attempts made to work them in more recent times, have been published. These are :—

1854. Haughton (**785**—1, 112). Describes the old workings in Kharsawan. A small quantity of copper, not amounting to 2 tons annually, was being produced in Seraikela and Dhalbhum.

1854. Ricketts (**1481**—1). A brief account of the old workings.

1855. Piddington (**1405**—73) Gives results of experimental smelting of copper slags sent to Swansea. The average yield of copper was 39·25 per cent. The slags contained about 50 per cent. Fe, which rendered them very refractory.

1857.–1864. Stoehr (**1711**—1) (**1711**—4) Full accounts of the geology of the copper belt and mode of occurrence of the ores. An abstract of these papers was published in the *Records, Geological Survey of India* (Vol. III, p. 86) in 1870.

1857—1858. Dürrschmidt (**519**—1; —2). Mainly a brief résumé of Haughton's and Stoehr's observations.

1870.–1881. Ball (**71**—9) (**71**—46, 143) A complete account of the old workings and of the geology of the region. In the earlier paper a list of localities is given at p. 100, with notes on the character of the ores observed at the outcrop, and of the rocks in which they occur.

1895. Oates (**1315**). A brief account of the copper belt, and history of attempts made to work the deposits.

1907—1909. Holland (**859**—60, 33; —66, 29; —71, 35). Reports on the progress of prospecting work carried out by means of borings.

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1910. Holland and Fermor (**861**, 234). A brief summary of the results of prospecting operations.

The ores are developed along a well defined horizon, near the base of the Dharwar (sub-metamorphic) series, either disseminated through muscovite and chlorite-quartz-schists, or forming indefinite lodes coinciding in direction with the bedding planes of the schists. They consist in depth of copper pyrites, but near the surface have been converted into carbonates and oxides. From these superficial deposits the ancients derived their supply of ore (**B.** 247).

Mining in recent times has been carried on, and experiments made in order to test the value of the deposits, at the following localities :—

JAMJURA (22° 43′ 30″ : 86° 10′). Worked by the Singhbhum Copper Co., 1857-59. A very rich band of malachite was followed to a depth of 15 fathoms.

KODOMDIHA (22° 46′ 30″ : 85° 53′). Boring. A lode 8 ft. thick, assaying 5·10 per cent. Cu, was struck at 392 ft. from the surface. Further to the deep, at 1,069 ft., the lode was 1 ft. thick, carrying 1·82 per cent. Cu.

LANDU or NADUP (22° 44′ : 86° 15′). Several mines in the neighbourhood were worked by the Singhbhum Copper Co. in 1857-59, and again in 1862-64. The ores were copper glance and malachite in lodes up to 3 ft. thick. The average yield of copper was 6 per cent. A recent boring here passed through a lode 14 ins. thick, carrying 3·33 per cent. Cu, at a depth of 197 feet.

LAUKISRA (22° 32′ : 86° 30′). Boring. Three bands of ore were passed through :—

	Depth.	Thickness.	Percentage of copper.
	ft.	ft. ins.	
1	150	16 10	2·65
2	169	1 10	2·13
3	179	4 8	1·37

MATIGARA (22° 38′ 30″ : 86° 26′). Worked by the Rajdoha Copper Co. from 1891 to 1908, when the Cape Copper Co.

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obtained an option on the property. Borings have passed through five bands of ore :—

	Depth.	Thickness.	Percentage of copper.
	ft. ins.	ft. ins.	
1	693 0	3 2	2·00
2	697 0	3 8	1·29
3	733 5½	2 1	1·01
4	736 1	0 3	12·81
. . . . .	736 5	2 0	0·42

RAJDOHA (22° 42′ : 86° 21′). Worked by the Rajdoha Copper Co. since 1891. Two workable ore bodies have been met with in a copper permeated formation 359 ft. thick. These are 2 ft. and 3 ft. thick, carrying 4·5 to 5·5 and 13·5 per cent. of copper respectively.

REGADIH (22° 47′ : 85° 48′). Boring. A lode 13 ins. thick, assaying 0·61 per cent. Cu., was met with at a depth of 197 feet.

The amount of copper ore produced in Singhbhum rose from 7 tons in 1909 to 8,984 tons in 1912, mainly due to the result of prospecting operations by the Cape Copper Co. at Matigara. The average annual output for the five years 1909 to 1913 was 3,115 tons. The amount produced in 1915 was 8,010 tons.

BOMBAY.

Ahmadnagar.—Small quantities of copper ore are said to be obtained by washing the sand of a stream at RASIN (18° 26′ : 74° 59′). The source of the ore is not known (**35**—25).

Bijapur.—Traces of copper ore were noted by Aytoun (**51**—2, 57) on the laminæ of talcose limestone at KACHERDAWI (? KHAJJIDONI, 16° 10′: 75° 31′), 4 miles from Kaladgi.

Dharwar.—Newbold (**1294**—29, 150) mentions having found small fragments of copper ore in the DHONI STREAM (15° 18′: 75° 47′), flowing from the Kappatgode hills ; and small quantities of copper pyrites were found by Foote (**596**—11, 140) near SURTUR (15° 15′: 75° 40′ 30″), in the same neighbourhood (**B.** 264).

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Kathiawar.—A thin vein of quartz containing copper pyrites very sparingly associated with galena was seen by Fedden (**569**—6, 134) traversing basalt at BANEJ-NES (? 21° 2′ : 70′ 59′), on the Machundri R., in the Gir hills.

Jacob (**924**—2, 87) states that copper ore is said to be found in the hillls running south from BHUDLI (?), and near NAWANAGAR (22° 28′ : 70° 8′).

Ratnagiri.—Copper pyrites was found by Aytoun (**51**—3, 83) in a quartz vein at VINGORLA HEADLAND (15° 51′ : 73° 40′).

BURMA.

Amherst.—O'Riley (**1340**—6, 23;—7, 27) states that he found heaps of copper slag at KYIEK MYRAM, a day's journey from Maulmein, and at two other localities further to the south. No ore was seen *in situ*. Fryar, in a letter to the Commissioner of Tenasserim, dated 26th July, 1873, mentions having visited a deposit of copper ore on the MEGATHAT (15° 25′ : 98° 20′), a tributary of the Ataran R. (**B.** 279).

A vein of ore containing silver, antimony, and copper is mentioned by Helfer (**808**—1, 14) as occurring in the Pagah range, between the Salween and Thon-khan rivers.

Chindwin (Lower).—The remains of an old copper mine are mentioned by Jones (**952**—4, 176) as occurring among volcanic rocks on LETPADAUNG HILL (22° 5′ : 95° 8′), 3 miles to the W. of the Chindwin R. at Monywa. Stains of green carbonate were the only signs visible of the presence of copper.

Kyaukpyu.—Some nodules found by Williams on ROUND I. (18° 42′: 93° 52′), to the S. E. of Cheduba, and described by Piddington (**1405**—14) and Mornay (**1254**—2) as consisting of native copper, were shown by Mallet (**1159**—14, 222) to be an artificial alloy of copper and tin (**B.** 278).

Mergui.—Helfer (**808**—6, 180; —7, 309) states that copper ore has been found on KALA KYAUK I, near Mergui, in gneiss; and on LAMPEI or SULLIVAN I. (10° 50′ : 98° 12′) in quartz veins traversing clay slate (**B.** 280).

Sagaing.—Traces of copper carbonate are said by Oldham (**1326**—17, 324) to occur at YEGA (21° 59′ : 95° 59′), in hornblendic slaty rock at the contact with a highly crystalline igneous dyke. The

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yield is said to be about 5 per cent. Cu. A specimen of malachite from Ava, assayed by Prinsep (**1436**—10, 15) which may have come from this locality, yielded 18·5 per cent. Cu.

Salween.—A specimen of copper ore obtained by O'Riley from a locality on the YUNZALIN R. was assayed by Waldie (**1866**—4), and described under the name of O'Rileyite. The principal constituents were (average of 2 samples):—Fe=39·29: Cu=14·56: As=35·57 per cent. One of the specimens contained 0·096 per cent. of silver (**B.** 278).

Theobald (**1763**—19, 94) reproduces a sketch map compiled by O'Riley showing two localities for copper ore on the western side of the Yunzalin R., not far above its junction with the Salween (17° 20′: 97° 44′). He also mentions the discovery by Foley of fragments of green carbonate of copper in the Botaung hills, 90 miles N. N. E. from Maulmein (**B.** 280).

Shan States (N.).—Minute grains of chalcopyrite, disseminated through the country rock, are found in association with galena at the silver-lead mines of BAWDWIN (23° 7′ : 97° 20′ 30″) in the Tawng Peng State. Thin films of malachite and azurite, resulting from the decomposition of the pyrites, also occur as incrustations along the shear planes of the rocks (La Touche and Brown, **1035**, 256).

An appreciable output of copper ore from the Bawdwin mines, worked by the Burma Corporation, Ltd., has been recorded since the year 1912. The total amount raised during the four years 1912-15 was 2,573 tons.

Mounds of copper slag were found by La Touche (**1034**—45, 371) near the village of LOI MI (23° 6′ : 97° 19′) about 3 miles to the W. of Bawdwin. No traces of the ore could be found *in situ*.

Fermor (**577**—9) records the receipt of specimens of schistose slate and vein quartz with chalcopyrite, chrysocolla, and malachite from near LETPANDAW (22° 24′ 30″: 96° 23′) in the Möng Lông State.

Shan States (S.).—Green carbonate of copper is worked, according to Jones (**952**—4, 194), at KYAUKTAT (KYAWK HTAP, 20° 51′: 96° 49′), and is said to yield 5 viss (about 18 lb.) of copper to two baskets of ore. The locality was not visited. Copper ore is also said to occur at TAUNGLEBYIN (20° 40′ : 96° 29′).

Middlemiss (**1219**—22, 150) records the occurrence of antimonial tetrahedrite with azurite and malachite at a number of isolated places round YATAUNG HILL (20° 57′ : 96° 38′), 4 miles to N. E. by N. of Myinkyardo. Surface workings were being carried on at

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GANAINGYA, 1¼ miles to the north. The ore occurs in limestone, in thin veins coinciding with the bedding planes. Copper ore is also said to occur 4 miles to W. N. W. of MAGWE (20° 38′ : 96° 36′), and in the stream beds near KWE-MA-SA (20° 43′ : 96° 32′).

CENTRAL INDIA AGENCY.

Gwalior.—Traces of malachite and azurite are reported by H. C. Jones (*see* La Touche, **1034**—39, 113) to have been found in a prospecting trench 2½ miles to the W. of KARHIA (25° 54′ : 78° 4′).

Indore.—Remains of old excavations in search of copper ore, and mounds of copper slag, were found by Bose (**173**—5, 69) at TAMKHAN (22° 27′ 30″ ; 76° 53′ 30″). The ore appears to have been worked out. The veins are said to have been 4 to 5 ft. wide, and to extend for about half a mile. Copper stains were also found in veins between KHARIA (22° 20′: 76° 46′), and JIWANI, 3 miles to the S. E., but no copper pyrites was seen *in situ* (*see* Holland, **859**—66, 49).

Rewah.—An old copper mine, situated about 1½ miles to the N. E. of CHERKA (24° 5′ : 81° 21′ 30″), has been described by Oldham (**1325**, 172). The workings were apparently of considerable depth ; but only stains of green carbonate were visible on the rocks forming the sides of the cutting.

No traces of copper ore were found by the Geological Survey officers near BARDI (24° 33′ : 82° 26′) or TAGWA (24° 16′ 30″ : 82° 1′), localities marked on Sherwill's map of Bengal (**1625**—11) as the sites of copper mines (**B.** 258).

CENTRAL PROVINCES.

Balaghat.—Excavations apparently made in search of copper ore, in a quartz reef forming a ridge at MALANJKHANDI (22° 1′ 30″ : 80° 47′), have been described by King (**987**—34). No indications of a lode were seen, but only small strings and incrustations of copper carbonate on the sides of the pits.

Chanda.—THANA WASA (19° 51′ : 79° 48′) is marked on the Atlas of India as the site of an old copper mine, but no further information is available (**B.** 257).

Drug.—Small quantities of green carbonate of copper were noted by Blanford (**148**—23) in a quartz vein containing galena, exposed about 3 miles to the W. of CHICHOLI (21° 4′ : 80° 44′). Similar

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traces were found by Ball (**71**—28, 185) in a quartz vein at WARARBAND (21° 4′ : 80° 53′ 30″), 16 miles to the E. of the Chicholi outcrop (**B.** 256).

Jubbulpore.—Copper pyrites associated with galena was discovered by Olpherts in the outcrop of a bed of quartzite, 2 miles to the N. of SLEEMANABAD (23° 38′ 30″ : 80° 19′), in 1870. Hughes (**888**—6) considered that there was no indication of a true lode, and that the deposit was of little value (**B.** 257).

Recent prospecting work has shown (*see Eng. Min. Journ.*, LXXXIII, 657) that the ore occurs in veins traversing dolomites of Dharwar age. Seven veins were disclosed, two of which measured 3 ft. and 4 ft. in width respectively. Selected samples of the ore were found to be very rich in silver, containing up to 200 oz. per ton. The results of the operations were not satisfactory, and the works were closed (**861**, 236).

Narsinghpur.—Ball (**71**—17) has described a deposit of copper ore discovered by Maynard in 1873 on an island in the Narbada R. close to BIRMAN GHAT (23° 2′ : 79° 5′). The ore consists of azurite and malachite with grey and red oxides of copper, and is disseminated through Bijawar schists, over a width of 6 to 14 feet. The presence of the ores was traced for a distance of 100 yards. Five specimens assayed by Tween yielded on the average 27·8 per cent. Cu. Two specimens assayed at the Mint yielded 32·75 and 23·1 per cent. of copper respectively (**B.** 257).

HYDERABAD.

Warangal.—Traces of copper ore are stated by Walker (**1868**—5, 183) to occur in granite at NALGONDA (17° 3′ : 79° 19′) ; and copper ore is said to have been mined on an island below YELGURRUP (?) in the Ramghir Sircar (**B.** 244).

KASHMIR.

Baltistan.—Specimens of copper glance and copper pyrites have been received from RONDU (34° 24′ : 77° 51′), but nothing appears to be known regarding their mode of occurrence (Lydekker, **1109**—38, 334).

Kashmir.—An old copper mine at HARPAT NAG (33° 50′ : 75° 23′ 30″) near Eishmakam is mentioned by Vigne (**1846**—4, Vol. II, 5). The ore occurs in a quartzose rock, which is much stained by the carbonates.

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Zangskar (Zaskar).—Large masses of native copper are stated by Lydekker (**1109**—22, 40 ; —38, 334) to have been found in the ZANGSKAR R., where it crosses the Tertiary rocks N. of the parallel of 34°, during the summer of 1878. La Touche (**1034**—14, 67) was informed that the copper is found considerably higher up the river, near YELCHUNG, (33° 55′ : 76° 58′), where it flows in a deep gorge through rocks of Triassic age. The existence of copper ores in the district had previously been conjectured by Cunningham (**399**—5, 234), who pointed out that the name Zangskar is derived from *zangs*, signifying copper (**B.** 267).

MADRAS.

Bellary.—Newbold has given three accounts (**1294**—13, 125 ; —29, 150 ; —43, 514) of the occurrence of green carbonate of copper on a ridge below the southern scarp of the COPPER MOUNTAIN, 5 miles to the W. of Bellary. He says that there is no distinct lode, but that thin layers of the ore are interlaminated with ferruginous slates. Excavations made under the orders of Hyder Ali on the crest of the mountain in search of copper ore were then visible (**B.** 241).

Foote, in 1896 (**596**—39, 197), could find no traces of copper ore on the mountain, but he mentions (*l. c.* pp. 172, 198) the occurrence of thin films and veinlets of the green carbonate permeating the quartz of a reef about a mile to N. N. W. of HARAPPANAHALLI (14° 47′ 30″: 76° 2′ 30″), where there are traces of an old mine. Copper stains were also found in a brecciated quartz reef at the crest of the Siddapan Konda ridge, 2½ miles E. by N. of HALLALGUNDI (15° 29′ : 77° 7′).

Coimbatore.—A quartz reef near HADABANATTA (ADAPULLNATTA, 11° 57′ : 77° 22′), formerly worked for gold, was found by Hayden (**793**—7, 62) to contain copper pyrites, malachite and bornite in fairly promising quantities. Samples from a newly opened portion of the reef near the surface yielded about 3 per cent. Cu. The old workings are fairly extensive, though not more than 20 ft. deep.

Cuddapah.—Traces of copper ore are mentioned by Newbold (**1294**—29, 150) and Foote (*see* King, **987**—7, 270) as occurring in the old lead mines at JANGAMRAJPILLI or BASWAPUR (14° 46′ : 78° 57′) in the Nallamalai hills. Cupreous stains and apparent impressions of copper pyrites are seen in strings of white quartz penetrating beds of siliceous limestone (**B.** 240).

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Guntur.—GANTLAPALEM or AGNIGUNDALA (16° 11′ : 79° 48′). Malachite and azurite occur as films on the joint planes of a bed of very coarse granular quartzite close to the village, according to Foote (*see* King, **987**—7, 269). Extensive mining operations had been carried on in former times. The locality was visited by Heyne (**834**—2, 108) in 1797 (**B.** 241).

Kurnool.—Copper ores have been described by Foote (*see* King, **987**—7, 268) as occurring at the following localities :—

GUMANKONDA (15° 38′ 30″ : 78° 21′). In an old pit sunk in a quartz vein at the western end of the valley, fragments of quartz coated with thin films of malachite were found. The vein appeared to have been entirely worked out (**B.** 240).

SOMADALPILLI (SOMAYAZULAPALLI, 15° 35′ : 78° 14′). Minute grains of copper pyrites and thin films of the carbonate were observed in a quartz vein, 4½ to 5 ft. thick, at the foot of the hills E. of the village (**B.** 241).

In the Kurnool Manual (**675**, 96) it is stated that copper ore was formerly worked near GANI (15° 40′ : 78° 22′ 30″), and that bell metal was manufactured here in the days of Rama Raja, a jaghirdar under the Vijayanagar dynasty. Traces of copper ore are also said to occur in GUJJALAKONDA (15° 45′: 79° 27′), and in KOMMEMARRI (15° 12′: 77° 55′ 30″).

Nellore.—The existence of old copper workings on an extensive scale in Nellore was first brought to notice by Heyne, who visited the district in 1800 and published his account in 1814 (**834**—2, 108). In the previous year Thomson, in a paper read before the Royal Society (**1776**—1), had described specimens of the ore collected by Heyne, and to one of these, considered to be an anhydrous carbonate of copper, he had given the name Mysorin. The old mines were worked at a number of localities in the neighbourhood of GARIMANIPENTA OR GANIPENTA (14° 59′ 30″ : 79° 37′), and have been described by the following writers :—

1829. Calder (**260**—1, 9). The old mines are mentioned, and the ore is said to yield from 50 to 60 per cent. of copper.

1833. Kerr (**982**). A note on specimens of the ore.

1835. Prinsep (**1436**—24; —27). Quotes an account by Kerr of the old workings, and of an attempt made to

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re-open the mines in 1831. Assays of 3 specimens of the ore are given, yielding 30·2, 39·5, and 69 per cent. of copper respectively.

1842. Ouchterlony (**1348**—2). Report on unsuccessful attempts made to discover payable copper lodes in the district.

1842. Newbold (**1294**—29, 151). A detailed account of the old mines at Garimanipenta and in the neighbourhood. The ores are said to occur as thin veins in hornblende schist. The most promising localities mentioned are NILAGANI, a quarter of a mile to the S., and SALIGIRI, half a mile to the S. W. of Garimanipenta.

1872. C. Æ. Oldham (*see* King, **987**—7, 270). Describes the mode of occurrence of the ore. Thin bands of the green carbonate, running through hornblende schists, were traced at intervals for a distance of more than a mile.

1873. Boswell (**174**, 60). Gives a brief history of recent attempts made to work the mines.

1879. Mallet (**1159**—19). Shows that the mineral described as Mysorin by Thomson is an impure malachite, owing its dark colour to ferric oxide and chalcocite.

1880. King (**987**—17, 185). A detailed description of the geology of the locality and mode of occurren e of the ore. An account of prospecting operations recently carried out by Lavelle is quoted. These, like all the attempts previously made, were confined to the oxidised ores lying near the surface ; and it is pointed out by King that the existence or otherwise of payable ore at a greater depth than 60 ft. has not been proved.

The surface ores, according to King, consist mainly of a mixture of chrysocolla, chalcocite, and malachite, with small quantities of copper pyrites. They occur in a band of hornblendic and garnetiferous schist, with which are associated intrusive sheets of trap. The ore is found chiefly in the trap, in strings and irregular masses, but there is no continuous lode.

Assays of 3 samples forwarded to Londom by Lavelle yielded 28·75, over 50, and 54 per cent. of copper respectively (**B.** 242).

Minute traces of malachite were detected by Foote (**596**—17, 103) at the northern end of a quartzite ridge near GOGULAPALLI (15° 15′ 30″ : 79° 22′ 30″).

Trichinopoly.—Stains of copper carbonates on gneiss, and waterworn fragments of cupriferous veinstone, were found by Blanford

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(**147**—8, 216) near OLAPADI (11° 19′ 30″ : 79° 9′) and VAPUR (11° 19′ : 79° 7′ 30″). The ore was not found *in situ* (**B.** 240).

MYSORE.

Chitaldroog.—Foote (**596**—34, 53) mentions old copper mines at BELLIGUDDA HILL (14° 19′ : 76° 31′). The ore was an earthy malachite, forming pockets of considerable size in schists, and had been worked-out. No signs of a lode were seen.

NEPAL.

Copper ores are known to occur in Nepal, but the localities have not been visited by a geologist. Medlicott (**1197**—39, 96) says that there are old mines on the northern side of the Sisagarhi ridge (27° 33′ : 85° 7′), and that they are situated near the junction of bedded quartzites with gneiss, along a broken anticlinal axis of flexure; but he was not permitted to inspect them. Buchanan-Hamilton (**222**—3, 76) has described the process of smelting the ore, which is similar to that practised in the Darjeeling district (*see under* **Bengal**). A variety of tetrahedrite obtained by Piddington (**1405**—57), from a locality near Khatmandu, and named by him Nepaulite, was found by Mallet (**1159**—46) to contain 38·69 per cent. of copper (**B.** 272).

PUNJAB.

Kangra.—Gerard (**650**—3, 263) and Hutton (**900**—4, 575) mention a copper mine near SUNGNAM (31° 45′ 30″ : 78° 32′) in **Kanawar.** The mine, according to Hutton, is situated between Sungnam and Rupa, at a height of about 4,000 ft. above the river Thanam. The ore occurs in quartz veins traversing Cambrian schist. The amount extracted was small, not more than 12 cwt., in 1837.

In Kulu the occurrence of copper ores at the following localities is mentioned by Calvert (**265**—2) :—

p. 6. CHISANI (31° 48′ : 77° 17′). Numerous old copper mines are to be seen on the hillside above the village. It is said that the lode can be traced for several miles. Henwood (**823**) examined the deposits in 1881, and says that copper pyrites is disseminated throughout the rocks over a wide area.

p. 73. JHARI (32° 0′ : 77° 18′). Mineral veins containing silver-lead and copper are said to abound in the neighbourhood, and there are many old workings.

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p. 23. MAOL (31° 55′ : 77° 11′). Large blocks of copper ore were found in the bed of the stream, but no lode was seen.

p. 68. SAOND (31° 54′ : 77° 13′). Masses of copper ore were seen on the slopes of Kot Kandi hill, above the village.

p. 71. SHATGHAR (31° 58′ : 77° 17′). Lodes of copper ore, hitherto unworked, were found in the bed of the stream.

Patiala.—Bose (**173**—21, 58) states that copper ores are widely distributed in the Narnaul district, occurring both in the Alwar quartzites and in the Arvali series. Old mines are very numerous in the southern portion of the district, especially near MOTAKA (27° 49′ : 76° 8′ 30″). Stains of malachite on quartz, phyllite, etc., were the only indications of ore met with.

Shahpur (Salt Range).—The occurrence of nodules of copper pyrites in beds of variegated clay associated with the Speckled Sandstone group has been noticed by Fleming (**591**—5, 257), Theobald (**1763**—1, 661), and Wynne (**1975**—18, 91). Fleming says that they are most abundant on the scarp above KATHA (32° 32′ : 72° 29′). The nodules vary from the size of a millet seed to that of a walnut, and consist of the sulphide with a coating of carbonate of copper. The quantity is insignificant; in fact, Wynne could find none of the nodules *in situ* (**B.** 266).

Simla.—An old copper mine exists near SOLAN (30° 55′ : 77° 10′), in the Simla Slate series ; but no information regarding it has been published (**B.** 266).

RAJPUTANA.

Ajmer.—Hacket (**730**—4, 247) observed traces of copper ore in the old iron workings near the jail at Ajmer.

Prinsep (**1436**—24, 582) has described specimens of copper ore collected by Dixon at three localities :—

GUGRA (26° 30′ 30″ : 74° 45′). Malachite with carbonate of lead and galena. Vein 4 ins. wide.

RAJAURI (RAJOSI, 26° 20′ : 74° 44′). Micaceous and ferruginous carbonate of copper.

RAJGARH (26° 18′ : 74° 41′). Red oxide of copper with malachite and ? chrysocolla, associated with carbonate of iron (**B.** 263).

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Alwar.—Hacket (**730**—2, 90 ; —4, 243) mentions the occurrence of copper ore at the following localities :—

BAGHANI (?). Workings abandoned for many years.

BHANGARH (27° 6′ : 76° 21′). Two or three small pits, fallen in.

DARIBO (27° 10′ : 76° 27′). Adit driven along the strike of slates, through which copper pyrites is disseminated. Occasionally rich pockets of ore are met with. Traces of ore also occur in slates on a ridge a short distance to W. of the village. Andresen (**31**) says that the ore occurs in a fissure vein, with an average width of 20 ins., along the junction of quartzites with black slates; and that it is traceable for over half a mile. He also describes the method of smelting the ore.

INDAWAS (27° 21′ 30″ : 76° 22′). A long open cutting 20 to 30 feet deep, from which the ore had been extracted.

JASINGPURA (27° 9′ 30″ : 76° 28′). Traces of copper ore found.

KUSHALGARH (27° 25′ : 76° 29′ 30″) } Old workings, abandoned
PERTABGARH 27° 15′ : 76° 13′) } for many years.

TASING (27° 53′ : 76° 16′ 30″). Traces of copper ore were seen (**B.** 259).

Bharatpur.—At NITHAHAR (26° 58′ : 77° 6′) a short level has been driven, and a small quantity of copper ore raised (Hacket, **730**—4, 247). Copper workings also formerly existed at BASAWAR (27° 2′ : 77° 7′), but in low grade ore (A. E., **524**—2 ; **B.** 260).

Bikaner.—Powlett (**1423**—1, 82) states that copper ore is said to have been extracted from a hill near BHADASAR (28° 18′ : 74° 22′), but not in paying quantities (**B.** 264).

Bundi.—Traces of copper ore were seen by Hacket (**730**—4, 247) in a small pit sunk in quartzites, about 2 miles to the E. of DATUNDA (25° 27′ : 75° 30′ 30″). A very small quantity appears to have been raised (**B.** 264).

Jaipur.—The following localities are mentioned by Hacket (**730**—4, 243) and others :—

BABAI (27° 53′ : 75° 49′). A few pits have been sunk, and a little copper ore was found disseminated through slates. The pits are said to be principally worked for *sehta*, or ore of cobalt (**B.** 263).

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BAGOR, *see* KHETRI.

GARH (26° 40′ : 76° 34′). Pit 20 or 30 feet deep. Traces of copper ore were found at the mouth of the pit, but none in the surrounding rocks.

KHETRI (28° 0′ : 75° 51′). A full account of the mines has been given by Brooke (**203**—2). Hacket (**730**—4, 245) says that they are situated near the crest of a ridge, about 500 feet above the plain. There are several shafts of considerable depth, leading to a gallery said to be upwards of 2 miles in length, and following the strike of the rocks. The ore, copper pyrites, occurs in small strings, and disseminated through the slates. According to Brooke, the ore, freed from gangue, is finely powdered, mixed with cowdung, and roasted before being smelted. Iron slag is used as a flux. The metal is refined by passing a strong current of air over it when in a molten state (**B.** 262).

LALSOT (26° 34′ : 76° 23′). Traces of copper were seen near a small excavation.

NABARO (27° 3′ : 76° 20′). A few small pits have been sunk and a little ore extracted. The debris is stained with copper.

SINGHANA (28° 6′ : 75° 54′). The earliest description of these mines was published in 1831 (A. E., **524**—2), and in 1835 Prinsep (**1436**—24, 581) remarked on the character of the ore. Hacket (**730**—4, 245) describes the mines as of large dimensions, excavated in a ridge of quartzite, several hundred feet above the level of the plain. Few traces of ore were seen, and these consisted of thin strings and nests of copper pyrites. The yield was from 2½ to 7½ per cent. of copper (**B.** 260).

The mines were visited in 1913 by Heron (*see* Hayden, **793**—31, 19), who reports that no copper is now produced, either here or at Khetri ; but that alum and soluble sulphates are still manufactured from the efflorescence which covers the walls of the galleries. The ore does not appear to be by any means exhausted.

UDHALA (27° 0′ 30″ : 76° 20′ 30″). Stains of copper are visible on the debris surrounding a few small pits.

Mewar (Udaipur).—MANDAL (25° 26′ 30″ : 74° 38′). Old copper mines here are mentioned by Hardie (**764**—7, 89).

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REWARA (25° 8′ : 74° 26′). A number of small pits has been sunk in schists for a distance of nearly a mile. Hacket (730—4, 247) thinks that, judging from the small quantity of slags found, the amount of ore raised was not large (B. 263).

Sirohi.—An old copper mine discovered by Major F. C. Hughes near ROHIRA (24° 37′ : 73° 1′ 30″) is mentioned by Griesbach (708—31, 45). There are large heaps of copper slag, but the excavations have been filled in. The ore, which contains a small quantity of gold, occurs in pyritous schists.

SIKKIM.

Copper ores are found at a large number of localities in Sikkim, most of which were visited and reported on by Bose (173—16, 223) in 1891. The ores occur among Archæan slates and schists, known as the Daling series, in the neighbourhood of great intrusions of granite, and often form well defined lodes, though they are also found in strings and nests permeating lenticles of quartz. They consist mainly of chalcopyrite, with iron pyrites, pyrrhotite, blende, and galena. The oxidised zone, containing the carbonates azurite and malachite, etc., which is so prominent in Singhbhum, is not so well developed here, owing to the rapid denudation of the surface along steep hill slopes under a heavy rainfall.

The following list of localities includes, in addition to those mentioned by Bose, several that have been discovered as the result of prospecting operations carried out in 1907-08 :—

BAM (27° 13′ : 88° 17′). An ore-bearing band 6 ins. thick occurs in slaty shales with quartz lenticles. Traces of the ore were found on both sides of the Risi stream.

BARMIAK (27° 13′ : 88° 33′). Traces of copper in some detached blocks of quartzite.

BHOTANG (27° 11′ : 88° 34′). There are some fairly extensive old workings here, situated in a precipitous scarp of slaty rocks overlooking the Teesta R. Recent development work has shown that there are two ore bands, about 3 ft. and 2 ft. 6 ins. thick respectively, separated by about 10 ft. of slates, and that these are fairly persistent. The ore consists of pyrrhotite with varying quantities of chalcopyrite, zinc blende, and galena. An average sample is said to have yielded 12·21 per cent. of copper.

CHUMBONG (27° 8′ : 88° 18′). Quartz veins, exposed by a landslip, are traversed by strings and nests of chalcopyrite, which has also impregnated the slates on either side. The principal vein is about 4 ft. thick.

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DAJONG (27° 18′ : 88° 26′). Green copper stains are seen on cliffs. Chalcopyrite was also found in some quantity in quartzose rocks at a spot a mile and a half to the E. of this locality.

DENTAM (27° 15′ : 88° 11′). About 2 miles along the road to Pemionchi a large mass of gneiss below the path is impregnated with copper pyrites.

DIKCHU or LINDOK (27° 23′ : 88° 38′). Recent prospecting operations have disclosed a lode 3 ft. in width, carrying 6·14 per cent. of copper. The lode has been followed for 200 ft. along the outcrop, and for 80 ft. in an adit, where it thickens to 40 ins., and contains 6·8 per cent. of copper. The ore here occurs in a zone of highly crystalline mica schist, between the Daling series and the Sikkim gneiss (*see* Hayden, **793**—26, 74).

JUGDUM (27° 10′ 30″ : 88° 17′). At an old mine copper pyrites occurs in strings and nests in large lenticles of quartz.

LINGUI (27° 13′ : 88° 42′). A cupriferous band about 100 yds. in length, and about 6 ft. thick, occurs in highly quartzose gneiss.

MIK (27° 8′ : 88° 24′). Strings of copper pyrites were observed in a large detached mass of quartzite.

MONGBRU (27° 17′ : 88° 21′). Copper pyrites occurs in clay slates, about a mile to N. E. of the village.

PACHIKHANI (27° 12′ : 88° 39′). Mines have been worked in two places, about a mile apart. The lode at the northern mine, open at the time of Bose's visit, was about 3 ft. in width, and yielded on the average 12 per cent. of copper. This mine has recently been destroyed by a landslip.

Lodes were found by Wilkinson (*see* **862**, 261) at the following places in the neighbourhood of Pachikhani:—(1) On the road from Rungpo to Pakyong, 7 miles from the former locality,—Chalcopyrite, concentrated in a zone of mica schist 4 ft. wide, yielded an average of 4 per cent. Cu. (2) Near the bridge between Rungpo and Rhenok,—A quartzose vein averaging 1 ft. in width, carrying 3·97 per cent. Cu. (3) Near Pakyong,—Two veins, one containing galena, the other 3·30 per cent. Cu. with lead, zinc, and iron sulphides.

RANGLICHU (27° 12′ : 88° 48′). Fragments of schistose quartzite with particles of copper pyrites and ? bornite. Not found *in situ*.

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RATHOKHANI (27° 9′ 30″ : 88° 17′). The mines here were being worked in 1874, when they were visited by Mallet (**1159**—6, 75), who calls the place Rattu. The ore occurs in lenticles of quartz, sometimes reaching large dimensions, as well as disseminated through the surrounding slates. These have been greatly shattered by faulting and pressure, and are full of water, so that mining is attended with great difficulty. Recent development has shown that there is no continuous lode. A sample selected by Mallet yielded 9·1 per cent. Cu. More recent samples, taken at irregular intervals along a length of 500 ft., gave an average of 5·6 per cent. of copper.

RINCHIMPONG (27° 14′ : 88° 18′). Copper ores occur in clay slate, and have been worked on a small scale.

SIRBONG (27° 11′ : 88° 19′). A lode of pyrrhotite with chalcopyrite is exposed, with an average thickness of 2 ft. 6 ins. The average yield, over a length of 100 ft. of outcrop, was 6·45 per cent. of copper.

TEMI (27° 14′ : 88° 27′). Chalcopyrite was found in some abundance in very hard quartzitic rocks in the Rimpichu, about 3 miles to W. N. W. of the village.

TUKKHANI (27° 7′ 30″ : 88° 25′). The ore in some old mines here is said to have been of excellent quality, but the galleries have fallen in.

UNITED PROVINCES.

Almora and Garhwal (Kumaon).—The copper deposits of the Kumaon division attracted a good deal of attention during the first half of the last century, when the native industry, which appears to have flourished at the time of the Gurkha occupation of the country, was in a moribund condition owing to the competition of imported copper in the local markets. Several descriptions of the old mines, noted below, were published ; but since the year 1855, when the last attempt was made to ascertain whether they could be profitably worked on modern lines, they received little attention till the beginning of the present century. It is therefore not always possible to identify the localities mentioned by the earlier writers. The subject is dealt with in the following papers and reports :—

1799. Hardwicke (**765**, 341)
1810. Raper (**1459**, 511)
1828. Traill (**1797**—3, 157)

} Mines at DHANPUR (30° 13′ : 79° 10′) and NAGPUR (30° 19′ : 79° 16′) in Garhwal are mentioned. Traill also alludes to those at GANGOLI (29° 39′ 30″ : 80° 6′) and SIRA (29° 48′ : 80° 18′) in Almora.

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1829. Herbert (**827**—6, 239). A general account of the mines. The ore at DHANPUR is said to yield from 30 per cent. to 50 per cent. Cu. The total production was about 2½ tons annually.

1835. McClelland (**1117**—2, 169, 180). The general conditions of the industry are discussed, and a description is given of the methods of dressing and smelting the ore, which are similar to those practised in the Darjeeling district (*see under* **Bengal.**).

1838. Drummond (**504**—1). A report on the mines at RAI (29° 43′ : 80° 5′) and SIRA. In both the lode had been worked for a distance of about 60 fathoms, and was said to have become richer in depth.

1839. Glasfurd (**664**). Reports progress in opening out the old mines at POKRI (30° 21′ : 79° 15′ 30″). The yield is said to be 10 per cent. to 20 per cent. of copper.

1842. Herbert (**827**—10, xcvi, cxix). Mentions old copper workings at POKRI and SIRA.

1843. Lushington (**1105**). A final report on the prospecting operations carried out at POKRI between 1838 and 1841. Details are given of seven mines, apparently situated on a single lode, which is developed along the contact of talcose schists with dolomite. The ore occurs at times in a well defined lode from 1 to 4 ft. thick ; but elsewhere in thin veins or strings distributed through 50 or 60 feet of rock.

1845. Reckendorf (**1467**). An optimistic but rather vague report on the mines at POKRI and DHANPUR.

1855. Beckett (**94**, 73). Describes a mine at AL AGAR (30° 0′ : 79° 20′) near Lobha in Garhwal, and the process of smelting. Ore is said to occur in thin veins in a band of quartz about 10 ft. in width. The yield is about 3 per cent. Cu.

1855. Henwood (**825**—1). A detailed report on the results of an inspection of the mines in both districts. The prospects of working them successfully on modern lines are not considered to be encouraging, except in the case of AL AGAR, where further prospecting is recommended.

1856. Barratt (**80**—1). Gives particulars of three new localities, PIPULI, PRINGLAPANI, and MARBUGETTI, in the Alaknanda valley, and an account of a visit to some of the old mines.

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1869, 1871. Lawder (**1040**—1, 87; —2, 19). Mentions a number of localities, and describes specimens of the ore.

1871. Henwood (**825**—3). A summary of the information gained during the inspection made in 1855.

1877. Atkinson (**48**, 20). A summary of the information given by previous writers, with a history of the attempts made to work the mines under European supervision.

1902. Stephens (**1694**—2). An account of the geology and mineral resources of Kumaon. The copper deposits are classified as (*a*) Irregular deposits, occurring in brecciated bands of limestone or dolomite from 15 to 30 ft., in width, traversed by two sets of quartz veins at right angles to each other. The veins are impregnated with chalcopyrite in depth, and with carbonates and chalcocite near the surface. The ore is often concentrated in bunches at the intersection of the veins. The yield is generally about 5 per cent. Cu. (*b*) Regular deposits, occurring in a zone of talcose schists, associated with a band of limestone extending for about 50 miles in a N. W. direction from PITHAGORA or PITHORAGARH (29° 35′ : 80° 16′). The ore, consisting of chalcopyrite, with carbonates and oxides near the surface, forms lodes from 2 to 6 ft. thick, and not often more than 6 ft. in length, in the talcose schists, or between the latter and the limestone.

Prospecting operations at RAI are described, and a map is annexed to the paper showing the position of the chief localities at which the deposits have been worked (**B.** 267).

Dehra Dun.—Blane (**145**, 61) mentions a copper mine, said to have been formerly worked, near KALSI (30° 32′ : 77° 54′).

Jhansi.—SAURAI (24° 19′ : 78° 50′). Rolled fragments of copper ore were found here in a fissure in Bijawar limestone (Mallet, **1159**—2). No lode could be found *in situ*. The ore, according to Piddington (**1405**—28), was the grey oxide of copper, tetrahedrite (**B.** 258).

COPPERAS *see* **SULPHATES—IRON.**

CORDIERITE *see* **GEM-STONES—IOLITE.**

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CORUNDUM.

A general account of Indian corundum was compiled by Holland in 1898 (**859**—25), in which the characters of the mineral, its geological relationships, its geographical distribution, and its economic uses were fully described. References to this monograph are distinguished below by the letter **H.**

ASSAM.

Khasi and Jaintia Hills.—Mallet (**1159**—20) in 1879 described some specimens of corundum, said to come from NONGRYNIEW (NORINGYAO, 25° 44′ : 91° 5′), a village in the Nongstoin State. According to Jackson (**921**), the mineral is found over a very wide area, but is chiefly collected at the villages of PATARKNANG (25° 38′ : 91° 13′) and NONGMAWEIT (25° 40′ : 91° 4′), and in the RIANDU R., a tributary of the Someshwari. It is found lying on the surface in fragments of a few pounds in weight, and at the third locality in large masses, probably weighing several tons. The corundum is a compact, finely granular, light grey rock. The sp. gr. is 3·93. It is taken to all parts of the hills for sale as hone stones.

The production in 1912, the only year for which returns are available, was 1,400 cwt. (**B.** 426; **H.** 21).

BIHAR AND ORISSA.

Cuttack.—Corundum is reported by Stirling (**1706**, 179) to be found in the NILGIRI HILLS (21° 25′ : 86° 45′), on the N. E. border of the district.

Hazaribagh.—Row (**1524**, 864) mentions an occurrence of corundum on the TUTKI GHAT (23° 57′ : 85° 42′), to the E. of Hazaribagh.

Manbhum.—An interesting discovery of corundum was made in 1896 by Warth (**1892**—23) at the village of SALBANNI (23° 4′ : 86° 20′). A blue variety of the mineral was found in a vein of kyanite from 2 to 3 ft. thick, enclosed in a band of coarse grained quartz rock following the boundary between the metamorphics and the transition (Dharwar) series. The vein was traced at intervals for a distance of 3 miles on either side of the village (**H.** 21).

Monghyr.—Corundum is stated by Hunter (**896**—2, Vol. XV, 31) to occur among the hills to the N. E. of JAMUI (24° 55′ : 86° 17′); but enquiries have failed to confirm the statement (**B.** 424; **H.** 22).

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Singhbhum.—An occurrence of corundum at LOPSO HILL (22° 48′ : 85° 48′) has been recorded by Fermor (**577**—21). The mineral occurs in granular crystalline aggregates associated with tremolite. It has not yet been found *in situ*.

CENTRAL INDIA AGENCY.

Rewah.—PIPRA (23° 58′ 30″ ; 82° 45′). The earliest accounts of the corundum quarries here were compiled in 1820 by Buchanan-Hamilton (**222**—5), and in 1845 by Sherwill (**1625**—3), from information obtained at Mirzapur, to which place the mineral was brought for sale. A full description of the deposit has been given by Mallet (**1159**—5, 20, 43), who visited the locality in 1872-73. The corundum is found in contact with a band of jade, followed by tremolite and quartz schists on one side, while on the other it is succeeded by prophyritic gneiss with hornblende rock. It appears to form a lenticular bed 30 yds. in width at the centre, but thinning out at one end of the outcrop to less than 10 yds. The total length of outcrop visible is about half a mile.

The corundum is a reddish or purplish grey rock, almost compact to finely crystalline in texture, with seams of emerald-green euphyllite, schorl, and diaspore.

The average annual output for the five years 1909 to 1913 was 787 cwt. (**B.** 424 ; **H.** 49).

CENTRAL PROVINCES.

Piddington (**1405**—40) has described specimens of corundum said to come from POHORA, a village "60 miles to the right of the Raipur-Calcutta road." The locality has not been identified (**B.** 424).

HYDERABAD.

Warangal.—Walker (**1868**—5, 187) states that fragments of corundum are found in the watercourses draining the KANNIGIRI HILLS (17° 20′: 80° 40′). They are also picked up in the fields, after rain, near the villages of GOBUGURU (17° 17′ : 80° 25′), BUNJUR (17° 15′ : 80° 25′), and GOLAGUDA (17° 15′ : 80° 21′), in the same neighbourhood (**B.** 424 ; **H.** 33).

MADRAS.

It has long been known that corundum is widely distributed in Southern India. Its occurrence in the Trichinopoly district was mentioned in 1798 by Greville (**706**—1) ; and the material used

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by Count de Bournon in his classical memoirs on the physical and mineralogical properties of corundum (**448**—1, —3) was mainly derived from the Madras Presidency. Heyne (**834**—2, 110) says that he picked up fragments the size of a hen's egg or larger near Bombartipudi, 24 miles from Tirupati in N. Arcot; and in 1844 Newbold (**1294**—38, 153) recorded a number of occurrences of the mineral in Southern India. Again, in 1857, Balfour (**69**—7) gave a full account of the materials found in the Presidency that are used as abrasives, including corundum and garnet. The lapidaries' wheel used in Madras has been described by Leschenault de la Tour (**1062**—3).

The corundum usually occurs, according to Holland (**859**—25, 11), as a primary constituent of basic rocks containing pyroxene and some form of spinel, either hercynite, pleonaste, or ruby-spinel. In most cases intrusions of pegmatite are found in the neighbourhood of the corundum-bearing rocks.

Corundum is known to occur at the following localities :—

N. B.—Except where otherwise stated, it is found in fragments scattered over the fields).

Anantapur—

Anantapur Taluk	Atmakur (14° 38′ 30″ : 77° 26′).
	Danduvarapalli (14° 39′ 30″ : 77° 46′).
	Paramatiyelaru (14° 40′ : 77° 26′).
	Pasalur (14° 39′ : 77° 44′).
	Reddipalli (14° 43′ : 77° 44′ 30″).
	Siddarampuram (?).
	Thimmapuram (14° 42′ : 77° 27′).
Dharmavaram Taluk	Maddalcheruvu Sivapuram (14° 26′ : 77° 26′).
	Motalachintarpalli (?).
Hindupur Taluk	Punighi (?).
Kalyandrug Taluk	Manirevu (14° 36′ : 77° 22′ 30″).
	Nutimadugu (14° 29′ : 77° 23′ 30″).
	Obalapuram (14° 37′ : 77° 22′).
	Palavenkatapuram (14° 33′ : 77° 24′). (**H.** 36).

Coimbatore Gopichettipalaiyam (11° 27′ : 77° 30′).
Kandyankovil (11° 1′ : 77° 32′).
Kangayam (11° 0′ : 77° 37′).
Karutapalaiyam (11° 3′ : 77° 35′). The mode of occurrence of corundum at this locality has been described

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by Middlemiss (**1219**—19, 47), and its origin discussed by Holland (**859**—34, 205). The corundum is considered to have been developed as an original constituent in a coarse grained felspar rock, surrounding a series of lenticular masses of elæolite syenite extending in a westerly direction from the base of Sivamalai hill, the main mass of which is formed of the same elæolite syenite. Both varieties of rock are considered to be contemporaneous in origin, and to be due to the differentiation of a magma of an alkaline nature, supersaturated with alumina (**H.** 37).

PADYUR (11° 4′ : 77° 33′).
SELANGAPALAIYAM (11° 26′ : 77° 38′).
SHIGRISPALAIYAM (11° 28′ : 77° 23′).

Salem.—PAPARAPATTI (12° 13′ : 78° 7′). Prospecting operations carried out by Middlemiss (**1219**—19, 43;—21) in this neighbourhood have shown that the corundum occurs in a number of lenticles, composed mainly of orthoclase felspar, disposed in parallel bands along the strike of a series of well foliated pyroxene granulites (charnockites), traversed by veins of coarse red and purple granite. Each corundum crystal is imbedded in a shell of a purer orthoclase than that forming the matrix of the lenticle. A quantitative experiment showed that the proportion of corundum may amount to 3·5 per cent. of the matrix. The band of lenticles, some of which measure 15 ft. in length, has been traced at intervals by surface indications for a distance of nearly 40 miles, from DONNAKUTTAHALLI (12° 0′ : 77° 57′) on the Cauvery to CHINTALAKUTTAI near RAYAKOTTAI (12° 31′ : 78° 6′)—(**H.** 41).

A similar occurrence of corundum was noted in an old pit situated a mile to the S. of the 6th milestone on the road from DHARMAPURI (12° 8′ : 78° 13′) to MORAPPUR. Fragments were also found at a spot two miles to the N. of the milestone.

RENGOPURAM (12° 9′ : 78° 0′). Abundant fragments occur at a spot 2 miles to N. by E. from the village.

SITTAMPUNDI (11° 14′ : 77° 58′). The area over which corundum is said to occur measures about 4 miles in length, by 2 miles in breadth at the widest part. Where seen *in situ*, the corundum is disposed in the form of porphyritic crystals through an anorthite-hornblende gneiss, associated with very coarse grained binary granite. The corundum crystals are of a greenish grey, rarely flesh colour, and are enclosed in a shell of calcite. The flesh coloured variety closely resembles the felspar of the granite, but may be distinguished from it by the trace of the cleavage planes, which

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appears on the crystal faces as a system of fine, parallel lines. A few are of a red colour, passing into ruby .(**H.** 39).

South Kanara . BANDAR (12° 52′ : 75° 23′).
ELLENIR (?).
HIREBANDADY (12° 48′ : 75° 19′).
KADIKAR (?).
KEMMAR (12° 49′ : 75° 20′ 30″).
MALEKAI (12° 46′ : 75° 36′).

All these localities are situated in the Uppinangadi Taluk. Their position suggests that they form a continuation in a N. N. W. direction of the corundum deposits of Mysore (**H.** 44).

The average annual output of corundum in the Madras Presidency during the four years 1910 to 1913 was 2,012 cwt.

MYSORE.

The existence of corundum in the Bangalore district was noted by Clark (**321**—2, 121) in 1839, and in the following year Newbold (**1294**—15, 46;—29, 219) described its mode of occurrence at GOLUSHALLI (?GOLLARHOSHALLI, 12° 59′ : 76° 28′) and KALKAIRI (12° 58′ 30″ : 76° 29′) in the Hassan district, where it was obtained from shallow pits along the outcrop of talcose schists penetrated by veins of pegmatite.

A considerable amount of prospecting work has been undertaken in recent years by officers of the Mysore Geological Survey, and the results have been published in the Records of that Department. The mineral usually occurs in loose fragments scattered through the soil or spread over the surface of the fields; but in some cases, noted below, it is found *in situ*. Holland has drawn attention to the fact that in certain cases the schists in which the corundum occurs adjoin basic and ultra-basic intrusions, associated with rocks made up almost entirely of granular hypersthene magnetic iron ore, and hercynite (**H.** 44-49).

The localities examined are :—

Bangalore.—(Primrose, **1431**—8, 218).
BANERKOTTA (12° 49′ : 77° 38′).
HOSHALLI (13° 26′ 30″ : 77° 31′ 30″).
HULKUNTE (13° 16′ 30″ : 77° 25′).
KODIHALLI (13° 11′ 30″ : 77° 31′).

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Hassan.—(Primrose, **1431**—10, 165).

AGRAHAR (13° 3′ : 76° 22′).
BELGUMBA (1 mile to S. W. of Agrahar).
GOLLARHOSHALLI (12° 59′ : 76° 28′).
HAGARE (13° 7′ 30″ : 76° 3′).
HOLE NARSIPUR (12° 47′ : 76° 18′).
NAGENHALLI (13° 14′ : 76° 15′).

Kadur.—(Evans, **555**—5; Primrose, **1431**—10, 165; Sampat Iyengar, **1549**—11, 68).

BYRLADHALLI (13° 26′ : 76° 4′).
KADAMANE (13° 26′ 30″ : 75° 18′). In a mica-chlorite layer at the contact of amphibolite rock with gneiss or pegmatite. Quantity small.
SUNKURDI (13° 25′ : 75° 18′ 30″). In highly decomposed amphibolite rock. Quantity small.

Kolar.—(Primrose, **1431**—8, 219; Venkataramaiya, **1838**—2, 92; —3, 166).

BEVINHALLI (13° 30′ : 77° 31′ 30″).
BOWRINGPET (12° 59′ : 78° 14′).
KAMASANDRA (12° 52′ 30″ : 78° 16′). In decomposed pegmatite veins and in boulders of a hard grey sericitic rock.
KORLAPATI (13° 33′ 30″ : 78° 2′).
MACHENHALLI (13° 32′ : 77° 30′). In pegmatite veins.
SIDILI (13° 37′ 30″ : 77° 56′).

Mysore.—(Evans, **555**—2; Primrose, **1431**—1; —2; —8, 216; Sambasiva Iyer, **1548**—11; Balaji Rao, **68**—1).

ANKANHALLI (12° 20′ : 76° 33′).
ARSINKERE (12° 30′ 30″ : 77° 5′).
BANNIKUPPE (12° 19′ : 76° 25′).
BASARALU (12° 42′ 30″ : 76° 53′).
BASVANHALLI (12° 21′ : 76° 57′). As deep red crystals, associated with a soft olive green mineral, in highly micaceous gneiss.
BELLUNDIGERE (12° 34′ : 77° 0′). As minute grains in micaceous gneiss.
BIDARHALLIBUNDI (12° 21′ : 76° 50′).
BOMMANHALLI (12° 19′ : 76° 35′). In highly micaceous gneiss and in a talcose matrix.

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Budihoskote (12° 26′ : 76° 33′).
Bugathalli (12° 24′ : 77° 5′ 30″).
Butgahalli (12° 22′ : 76° 54′).
Chaudanhalli (12° 44′ : 76° 28′ 30″).
Chattanhalli (12° 12′ : 76° 37′). As small dark crystals in a white matrix.
Chik Bichanhalli (12° 17′ 30″ : 76° 30′).
Dharmapur (12° 14′ : 76° 26′ 30″).
Golambede (?).
Gumsihalli (12° 11′ 30″ : 76° 32′). In a massive grey crystalline rock intrusive in gneiss.
Gurdevarhalli (12° 31′ : 77° 5′ 30″).
Hunsur (12° 18′ : 76° 21′).
Kampagowd Koppal (12° 24′ : 76° 58′ 30″).
Kaniyanbundi Hosur (12° 14′ : 76° 33′). In a matrix of softer grey crystals.
Kiragandur (12° 31′ : 76° 55′ 30″).
Kupya (12° 17′ : 76° 53′). As small red crystals, enveloped in a pale pinite-like mineral, in graphitic and talcose, highly micaceous gneiss.
Linghapur (12° 43′ : 76° 30′).
Madgahalli (12° 21′ 30″ : 76° 54′ 30″).
Manikpur (12° 18′ : 76° 35′). In a pale greenish steatitic material.
Mariyanhundi (12° 17′ : 76° 32′).
Nadappanhalli (12° 15′ 30″ : 76° 26′ 30″). In a matrix of soft dark grey crystals, forming rounded masses in a decomposed talcose schist. The deposit was being systematically worked in 1898.
Nelimakanhalli (12° 25′ : 77° 6′). In a thin irregular vein in a matrix of pale decomposed calcareous rock.
Nughalli (12° 17′ : 76° 35′). Black corundum occurs sparingly in a granitoid mass of steatite-like material.
Punjur (11° 46′ 30″ : 77° 10′ 30″).
Pura (12° 28′ 30″ : 77° 0′).
Ramanhalli (12° 30′ : 76° 57′).
Ramnatpur (?).
Sannakikoppal (12° 21′ : 76° 58′). As separate crystals or massive aggregates in a soft, friable and decomposed white material, apparently originally hornblendic gneiss. In one pit associated with a porphyry dyke.
Sargur (12° 15′ : 76° 34′).
Satnur (12° 33′ 30″ : 76′ 58′).

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SHENAPATAHALLI (12° 18′ 30″ : 76° 54′).
SHIBENHALLI (12° 35′ : 77° 7′).
SINGANMARNAHALLI (12° 12′ : 76° 30′).
TAGHALLI (12° 29′ : 77° 0′).
TARASANHALLI (12° 31′ : 76° 54′).
TARVALLI (12° 1′ 30″ : 76° 59′ 30″). In an irregular vein 1 to 2 ft. wide, between decomposed gneiss and micaceous talcose rock.
TIPPUR (12° 30′ 30″ : 77° 11′).
VADDAR HOSHALLI (12° 17′ : 76° 29′). As small crystals in a soft dark grey mineral.
WADDARPALAIYA (12° 16′ 30″ : 76° 50). In pegmatite.
YELCHODI (12° 19′ : 76° 30′).
YERAHALLI (12° 31′ : 76° 53′).
YEREKALMONTI (¾ mile to S. W. of Bommanhalli). As minute granular crystals in a thin band of mica schist; also in a vein of pegmatite 1 ft. wide.

Tumkur.—(Primrose, **1431**—8, 218).

Corundum is reported to occur at several places in the following Taluks :—

KORTAGERE (13° 31′ : 77° 18′).
KUNIGAL (13° 1′ : 77° 5′).
MADDAGIRI (13° 40′ : 77° 16′).
PAVAGADA (14° 6′ : 77° 20′ 30″).
SIRA (13° 44′ 30″ : 76° 58′).

The exact localities are not mentioned.

The average annual output of corundum in Mysore, during the quinquennial period 1909 to 1913, was 2,434 cwt. The greater portion of the production of this mineral recorded in India during 1914 and 1915, namely 2,360 and 1,246 cwt. respectively, came from this State.

NEPAL.

Buchanan-Hamilton (**222**—3, 79) states that corundum is found in detached masses on the hill slopes near Isma and Musikot(?). It is said to occur in large quantities.

DIAMOND, *see under* **GEM-STONES.**

DICHROITE, *see* **GEM-STONES—IOLITE.**

EPSOMITE, *see* **SULPHATES—MAGNESIUM.**

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FIRE-CLAY.

ASSAM.

Khasi and Jaintia Hills.—Samples of clay obtained by Bose near JAWAI (25° 26′ : 92° 16′) have been tested by Messrs. Burn and Co., and found to make excellent fire-bricks, capable of withstanding great heat. Good coal occurs in the neighbourhood (*see* Holland, **859**—38, 10).

Lakhimpur.—A sample of crude clay from the coal measures at MAKUM (27° 18′ : 95° 41′), when exposed to a temperature sufficient to melt wrought iron, was found by Smith (**1665**, 60) to exhibit indications of softening to a certain extent. The quality of the clay might be improved by washing out the iron pyrites and coaly matter which it contains.

BIHAR AND ORISSA.

Bhagalpur.—Sandy clays suitable for the manufacture of fire-bricks are interstratified, according to Blanford (**147**—11, 146) with the white pottery clays of PATARGHATTA HILL (25° 20′ : 87° 18′) near Colgong. The results of experiments on these clays, conducted by O'Shaughnessy, were published in 1839 in the *Bengal Dispensatory and Pharmacopœia*, p. 700. Crucibles and fire-bricks made from them were considered to be equal in quality to articles imported from Europe (**B.** 568).

Manbhum.—A series of tests carried out by Hughes and Medlicott (**889**) on fire-bricks made from clay obtained in the neighbourhood of MALLAPUR, in the Raniganj coal field, showed that compared with Glenboig fire-bricks they were inferior, but compared with Stourbridge bricks they were somewhat superior. At the temperature at which the experiments were conducted, considerably higher than the melting point of cast iron, the edges of the bricks resisted fusion, but all were cracked to some extent (**B.** 568).

Santal Parganas.—Many of the beds of clay associated with the inferior coal seams exposed on the western side of the Rajmahal hills have been found to furnish material suitable for the manufacture of fire-bricks. An exhaustive series of trials of clay from a number of localities has recently been made by Murray Stuart (**1723**—3, 138). The following particulars of the thickness of the beds and quality of the material are abstracted from his report :—

BARGO 24° 31′ : 87° 27′). { 1. 1 ft. / 2. 2 ft. } Infusible.

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BHULGORA (24° 57′ : 87° 28′). 8 ft. Vitrifies slightly.

BORA GHAT (25° 1′ : 87° 26′). 1. 2 ft. 2. 4 ft. } Infusible.

BURARI (24° 57′ : 87° 29′). 2 ft. 6 ins. Infusible.

CHILGO (24° 33′ : 87° 31′). 3 ft. Vitrifies slightly.

DHUMNI (24° 47′ 30″ : 87° 32′).
1. 3 ft. Vitrifies slightly.
2. 3 ft. 6 ins. Infusible.
3. 3 ft. 9 ins. Vitrifies slightly.
4. 4 ft. Infusible.
5. 3 ft. Vitrifies slightly.
6. 3 ft. 9 ins. Vitrifies slightly.

DHUMABHITA (24° 42′ : 87° 33′). 4 ft. Infusible.

GILHURRIA (24° 51′ : 87° 28′). 3 ft. Infusible.

GUGRI (24° 44′ : 87° 31′). 1. 4 ft. 2. 4 ft. } Infusible.

HURA (24° 59′ : 87° 27′).
1. 2. ft. 6 ins. Infusible.
2. 2 ft. 3 ins. Fusible and useless.

JIAJORE (24° 46′ : 87° 28′ 30″). 1. 2 ft. Vitrifies slightly. 2. 4 ft. Infusible.

KHIJARIA (24° 12′ : 87° 19′). 6 ft. Vitrifies slightly.

LOHANDIA (25° 3′ : 87° 26′). 1. 3 ft. 2. 3 ft. } Infusible.

NARGANJO (24° 25′ : 87° 27′). 1 ft. 6 ins. Vitrifies slightly.

ROHRI (24° 59′ 30″ : 87° 28′). 1. 2 ft. 9 ins. 2. 4 ft. } Infusible.

SALDUHA (24° 19′ : 87° 34′ 30″). 4 ft. Vitrifies slightly.

SIMLONG (24° 45′ : 87° 30′).
1. 2 ft. 3 ins. Infusible.
2. 8 ft. Vitrifies slightly.
3. 2 ft. Infusible.

SIMRU BUNGALOW (25° 2′ : 87° 24′).
1. 3 ft. Infusible.
2. 2 ft. Vitrifies very slightly.

SIMRU GHAT (25° 1′ : 87° 23′). 2 ft. Infusible.

SURWA (24° 27′ : 87° 32′) 1. 10 to 15 ft. Vitrifies slightly. 2. 3 ft. Infusible.

TELBHITA (24° 48′ : 87° 28′ 30″) 1. 4 ft. Vitrifies slightly. 2. 3 ft. Infusible.

UMBAPANI (24° 16′ 30″ : 87° 35′). 3 ft. Vitrifies slightly.

BURMA.

Amherst.—Turner (**1819**—3) has reported the occurrence of fire-clay of excellent quality near the military cantonment at MAULMEIN

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(16° 30′ : 97° 40′). O'Riley (**1340**—3, 742) also states that it is found on the banks of the Gyaing and Ataran rivers, but does not give the exact localities.

CENTRAL INDIA AGENCY.

Gwalior.—A bed of soft white clay in the lower portion of the Morar group exposed near RAIPUR (26° 8′ : 78° 8′) is considered, from tests made by H. C. Jones (*see* La Touche, **1034**—39, 97), to be capable of furnishing good fire-bricks.

Rewah.—In the neighbourhood of Umaria thick beds of white clay belonging to the Jubbulpore group (upper Gondwana) crop out from beneath the Lameta limestones. Samples of some of these clays were tested by Mallet (**1159**—36, 114; —52, 142), and found to be quite infusible, while others softened slightly at a white heat. They have been observed at the following localities, but probably occur in many other places :—

AMDARI (23° 28′ 30″ : 80° 40′). "Occurs in considerable quantity."

BAROUDI (23° 0′ 30″ : 80° 44′). About 40 ft. of white clay and earthy sandstone.

MAHANADI R., W. of CHANDIA (23° 39′ : 80° 46′). Beds of white and greyish white clay, 4 to 5 ft. thick, exposed for a distance of more than a mile on both banks.

A sample from a seam of greyish white clay, 3 ft. thick, exposed in a railway cutting close to the UMARIA colliery, and met with in all the wells in the vicinity, was found on being tested to be quite infusible.

CENTRAL PROVINCES.

Chanda.—Bunning (**231**, 91) has recorded the existence of a stratum of fire-clay, 11 ft. 3 ins. in thickness, at the WARORA colliery, above No. 2 seam. The lower portion, 3 ft. 9 ins. thick, is a pure white clay.

Jubbulpore.—Some of the white upper Gondwana clays, now largely used in the pottery works at JUBBULPORE, have been tested by Mallet (**1159**—36, 114; —52) and found to be exceedingly refractory. Samples exposed for an hour to a white heat showed no signs of fusion, but contracted 1-14th in length, and became sufficiently hard to scratch glass. The clays contain less than 1 per cent. of lime and magnesia respectively.

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HYDERABAD.

Voysey (**1853**—5, 246) remarks that the steel manufacturers at KONE SAMUDRAM (18° 44′ : 78° 35′) use clay obtained locally for building their furnaces and making crucibles. It is said to be highly refractory, but becomes semi-vitrified when exposed to long continued heat.

MYSORE.

Bangalore.—Sen (**1606**—4, 137) has described a deposit of clay occurring a mile and a half from GOLHALLI (13° 9′ : 77° 29′), which is used by the City Tile and Brick Works at Bangalore for the manufacture of fire-bricks. About 600 tons are used annually.

FLUOR-SPAR.

CENTRAL INDIA AGENCY.

Rewah.—Mallet (**1159**—3, 122) states that he has observed fluor-spar in the Bhander (Upper Vindhyan) limestones, but in quantity so small as to be of no economic value (**B.** 449).

CENTRAL PROVINCES.

Drug.—Fluor-spar is associated with galena and carbonate of copper in a quartz vein traversing gneiss at CHICHOLI (21° 4′ : 80° 44′), and has been described by Oldham (**1326**—45) and Blanford **148**—23). It appears to occur in small quantities only (**B.** 449).

Jubbulpore.—Minute crystals of fluorite have been detected by Fermor (**577**—5) in a vein of altered quartz porphyry, carrying ores of copper and lead, at SLEEMANABAD (23° 38′ 30″ : 80° 19′).

PUNJAB.

Kangra (Bhabeh).—Light green crystals of fluor-spar were detected by Mallet (**1159**—1, 166) among the minerals of albite-granite veins at WANGTU BRIDGE (31° 32′ : 78° 4′). They were of very rare occurrence (**B.** 449).

RAJPUTANA.

Kishangarh.—An occurrence of fluor-spar at BARLA (26° 29′ : 75° 1′ 30″) is mentioned in the Quinquennial Review of mineral production (**862**, 267). The mineral apparently forms a vein with calcite and quartz, about a foot in thickness, traversing gneiss.

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FULLER'S EARTH.

Fuller's earth is used in India not only for the washing of cloth, but constitutes the principal part of the various earths that are sold in the bazaars for edible purposes. The earth-eating habit, which is prevalent in all parts of the country, has recently been made the subject of an exhaustive monograph by Hooper and Mann (**869**).

ASSAM.

Manipur.—An unctuous clayey rock obtained, according to Oldham (**1324**—3, 241), from a small hill to the left of the main road leading northwards from the city of Manipur, is sold in the bazaar as a delicacy to which medical virtues are attributed.

BIHAR AND ORISSA.

Bhagalpur.—Fuller's earth is said to be associated with the pottery clays of PATARGHATTA HILL (25° 20′ : 87° 18′), and is mentioned by Ball (**71**—26, 240) as being sold in the Calcutta bazaars under the name of *Rajmahal mitti*. It is known locally as *sabun mitti*, =soap-earth (**B.** 565, 570).

BOMBAY.

Sind.—Blanford (**48**—63, 195) states that a pale greenish clay found in the southern portion of the Laki range, and near Hyderabad (25° 23′ : 68° 26′), is used for washing cloth, etc., and is eaten by pregnant women (**B.** 571).

CENTRAL PROVINCES.

Jubbulpore.—In the Quinquennial Reviews of mineral production issued by the Geological Survey (**861**, 230; **862**, 252), a considerable amount of fuller's earth is recorded as having been raised at KATNI (23° 50′ : 80° 28′), where it occurs in Lower Vindhyan rocks. The average annual output for the five years 1909 to 1913 was 100 tons.

HYDERABAD.

Heyne (**834**—2, 273) mentions having found fuller's earth in this State, but gives no particulars regarding the locality.

MADRAS.

Anantapur.—Outputs of 30 and 52 tons of fuller's earth in the years 1911 and 1912 respectively are recorded from this district

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in the Quinquennial Review of mineral production for 1909 to 1913 (**862**, 253), but no particulars of the locality or nature of the deposits are given.

PUNJAB.

Dera Ghazi Khan.—Ball states (**71**—45, 571), on the authority of Captain Pollock, that about 360 tons of a clay resembling fuller's earth were imported annually from the interior of the SULEIMAN RANGE. A variety called *sabz mitti*, =green earth, used for cleansing the hair, was also brought to Multan from VADUR (30° 5′ : 70° 36′), to the amount of about 7 tons annually.

Shahpur (Salt Range).—A lavender coloured clay, considered to be a decomposed volcanic ash, exposed in the Nilawan ravine S. of NURPUR (32° 40′ : 72° 39′) and elsewhere, is used according to Wynne (**1975**—18, 300), as a detergent (**B.** 571)

RAJPUTANA.

Ajmer.—Fuller's earth is said by Irvine (**910**—1, 164) to have been obtained near AJMER from fissures in quartz and schistose rocks, with carbonate of lime (**B.** 570).

Bikaner.—The yellow unctuous clay widely known in India as *Multani mitti*, and used in a half-baked condition as a comestible, is quarried on a large scale at the village of MAR or METH (27° 51′ : 73° 0′) near Kolaith, and exported to Multan and other towns in Northern India. According to Powlett (**1423**—1, 97), writing in 1874, about 2,000 camel loads were sent from the quarries annually. The clay is of Eocene (nummulitic) age (**B.** 370).

Thick beds of a similar clay were met with, interstratified with nummulitic limestone, in sinking the well at PALANA (27° 51′ : 73° 19′) in which coal was discovered in the year 1896 (La Touche, **1034**—24, 123). A considerable quantity was raised and exported during the progress of the prospecting operations.

Jaisalmer.—Oldham (**1324**—18, 160) mentions the occurrence of *Multani mitti* at the village of MANDAR, about 5 miles to the N. of KHEWALSIR (27° 15′ : 70° 54′). It is quarried and exported on a considerable scale.

The amount of fuller's earth raised in Bikaner and Jaisalmer in the year 1904 was 534 tons, according to the Quinquennial Review of mineral production for 1904-08 (**861**, 230). No returns appear to have been received for succeeding years.

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Marwar (Jodhpur).—Large quantities of fuller's earth or *Multani mitti* are quarried, according to Walter (**1879**, 57) at Kapuri (?) in Barmer, and exported to Sind, etc. A production of 1,000 tons is recorded for the year 1913 (**862**, 253).

GADOLINITE, *see under* **RARE MINERALS.**

GARNET, *see under* **GEM-STONES.**

GEM-STONES—AGATE.

Agate and its varieties, carnelian, onyx, etc., are of common occurrence in the amygdaloidal flows of the Deccan and Rajmahal traps, and the chief sources of supply are the rivers that drain the areas covered by these rocks. A list of the minerals that are derived by weathering from the Deccan trap was given in 1844 by Newbold (**1294**—38, 37), who particularly mentions the beds of the Kistna, Godavari, and Bhima rivers, and the plain of Bijapur in the Bombay Presidency, as affording agate pebbles. They are also found in abundance in the valley of the Narbada, especially at BHERAGHAT, or the MARBLE ROCKS (23° 7′ : 79° 51′), whence the material employed by the lapidaries of Jubbulpore is largely derived. Localities specially mentioned by other writers are noted below.

BIHAR AND ORISSA.

Santhal Parganas.—Nodules of **agate**, derived from the flows of amygdaloidal basalt which overlie the Gondwana coal measures, are found in some abundance among the Rajmahal hills, but have hitherto been neglected by the inhabitants. Sherwill (**1625**—14, 48) especially mentions a locality 2 miles to the N. of BURHAIT (24° 53′ : 87° 40°), in the centre of the hills, where a bed of agate nodules extends for a mile from east to west (**B.** 505).

BOMBAY.

Ahmadabad.—Veined **agates** from RANPUR (22° 21′ : 71° 46′) are mentioned by Campbell (**274**) as the most valuable material worked into ornaments by the lapidaries of Cambay. They are found near the surface in pebbles of various shapes, not more than ½lb. in weight, and take a high polish (**B.** 508).

Kaira.—The town of KAPADVANJ (23° 2′ : 73° 8′) has given its name to a variety of **agate** much prized by the lapidaries of Cambay. It is found at Kapadvanj itself, and in the bed of the Majam R.

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between MANDVA and AMLIYARA (23° 13′ : 73° 6′), in kidney and almond-shaped balls from ½lb. to 10lbs. in weight. Some of the pieces are of the variety known as **landscape agate** (**B.** 508).

Kathiawar.—Fedden (**569**—6, 134) mentions the occurrence of a large irregular vein of **moss agate** in decomposed amygdaloidal trap at KHIJARIA, 3 miles to the W. N. W. of TANKARA (22° 40′ : 70° 48′ 30″) in the Morvi State. It is also found, according to Summers (**1726**—1, 319), in massive blocks forming layers about 2 ft. below the surface. **Common agate** of a greyish white colour is found in the same neighbourhood. The stones are purchased by traders from Cambay, where they are worked up into ornaments (**B.** 508).

Adye (**11**, 60) gives the following additional localities for **moss agate** :—LATIPUR (22° 37′ 30″ : 70° 35′) and the villages of TIMBRI, OTALA, and THORIALI, within 7 miles to the E. N. E. and S. E. of this town; also between JIWAPUR (22° 49′ : 70° 40′ 30″) and BADANPUR (22° 47′ 30″ : 70° 40′). At these places it occurs in fragments scattered over the surface of the ground. It was found in a vein exposed about half a mile to S. W. of KHAKHRA (22° 22′ : 70° 30′). Adye has also described (*l. c.*, 143) extensive beds of **agate** and **chalcedony** conglomerate, forming old river terraces in the neighbourhood of VERATIA (22° 23′ : 70° 26′).

Rewa Kantha (Rajpipla).—The chief source from which the **carnelian** and **agate** workers of Cambay are supplied is situated in the State of Rajpipla, near the village of RATANPUR (21° 43′ 30″ : 73° 14′ 30″). The industry is said to have flourished for more than 2,000 years, but according to Bose (**173**—23, 176), the first authentic accounts of it date from the beginning of the sixteenth century, when an Abyssinian merchant named Bawaghor is said to have established an agate factory at LIMODRA (21° 44′ : 73° 12′ 30″), between Ratanpur and the Narbada, where the preliminary operations in the treatment of the stones are still carried on. The subject has been dealt with by the following writers :—

1727. Hamilton (**744**, Vol. I, 143). Mentions the agate industry of Cambay.

1788. Hove (**873**, 51). Describes the process of polishing the carnelians.

1813. Milburn (**1224**, Vol. I, 278). Gives statistics of the sale of carnelians for the years 1804 to 1808.

1815. Copland (**361**—1; —2). A full description of the mines and of the method of treating the stones.

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1815. Barnes (**77**). A brief accoun tof the industry.

1821. Willoughby (**1938**, 269). Describes the mines, and gives statistics of the yield.

1827. Kennedy (**980**). An account of the mines compiled from information obtained in Cambay.

1835. Lord (**1091**—1). Describes the process of manufacturing ornaments.

1836. Lush (**1104**—1, 766). A brief account of the mines.

1838. Fulljames (**629**—4). Account of a visit to the mines.

1851-1854. Summers (**1726**—1; —2). A full description of the carnelian and agate trade of Cambay.

1853. Anon. (**35**—15). A brief account, with statistics of export.

1867. Blanford (**148**—22, 381). A brief notice. The agate bearing gravels are stated to be of Tertiary age.

1881. Campbell (**274**). A detailed summary of the information given by previous writers (*see also* Ball, **71**—45, 506).

1908. Vyas (**1856**). Describes the present condition of the mines, and the method of preparing the stones for market.

1908. Bose (**173**—23, 176). A full description of the geology of the area, with notes on the mining methods employed and the treatment of the stones.

The conglomerates in which the agates occur cover an area of about 4 square miles, and are of Pliocene age, according to Bose. The most valuable stones are found in a stratum of ferrugineus clay, not more than a foot in thickness, which is worked at a depth of between 25 and 70 feet from the surface. The system of mining is extremely primitive and wasteful, since the shafts are abandoned and become filled in during each monsoon, and fresh ones must be sunk at the beginning of the dry season, when work is resumed. The stones extracted are taken to Limodra where they are exposed to the sun for about 4 months, and are then partially baked in earthen pots over a slow fire, in order to improve the colour. The stones are then chipped in order to exhibit the colour and ascertain whether they are flawed or cracked, and are finally sent to Cambay to be worked into bowls, knife-handles, beads, etc.

The production of 'carnelian stones' from the Rajpipla mines recorded in 1913 was 103 tons, valued at £250. In 1914 it was practically the same, 101 tons valued at £175; but in 1915 the output increased to 508 tons, valued at £1,019.

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KASHMIR.

Rudok.—Godwin-Austen (**669**—8, 362) mentions the occurrence of fine **agates** and **carnelians** in a small ravine at the spot where the southern spur from Chamkang abuts on the KYAMGO TRAGGAR (34° 20′ : 79° 18′), to the N. of the Pangong Lake.

MADRAS.

Godavari.—Benza (**110**—4, 53) states that large quantities of **agate, jasper** and **carnelian** pebbles are collected from the bed of the Godavari R. near RÁJAMAHENDRI (17° 0′ : 81° 50′).

Guntur.—Newbold (**1294**—23, 936) alludes to the abundance of pebbles of **agate, onyx,** etc., that are found in the alluvium of the Kistna R. in the Palnad.

AMETHYST.

BIHAR AND ORISSA.

Santal Parganas.—Geodes of quartz lined with crystals of **amethyst** sometimes measuring several inches in length are stated by Sherwill (**1625**—9, 576) to occur in a bed of **chalcedony** exposed at the foot of a range of basaltic hills, 2 miles to the W. of BURHAIT (24° 53′ : 87° 40′).

CENTRAL PROVINCES.

Jubbulpore.—Small **amethysts**, occurring in Deccan-trap geodes, are collected from the bed of the Narbada R. near Jubbulpore, and used for jewellery and beads (**862**, 269).

HYDERABAD.

Malcolmson (**1158**—7, 102) and Newbold (**1294**—51, 483) mention the occurrence of amethystine quartz in granite in the neighbourhood of Hyderabad. Heyne (**834**—2, 264) also mentions the occurrence, and says that **opal, chalcedony**, and **carnelians** are also found here.

PUNJAB.

Bashahr.—**Amethyst** is found at several localities in the valley of the Sutlej R., according to Hayden (**793**—9, 102).

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APATITE.

BURMA.

Ruby Mines.—**Apatite** in well defined crystals of a beautiful and unusual blue colour is sometimes found in the *byon*, or gem-gravel of Mogôk (Brown and Judd, **208**, 212).

MADRAS.

Vizagapatam.—Fermor (**577**—32, 206, 1073) mentions a discovery of **apatite** crystals, of a beautiful deep sea-green colour, at DEVADA (18° 15′ : 83° 37′ 30″). The crystals measure up to 5 ins. in diameter, and occur in a spandite-felspar rock. Several hundredweights are said to have been obtained. A veinlet of lavender coloured **apatite** was also found in spandite-rock at the manganese mine of KODUR (18° 16′ 30″ : 83° 36′ 30″), but the mineral is much flawed (*l. c.*, 205).

BERYL.

Beryls of large size are occasionally met with in the mica-bearing pegmatites of Bihar and Nellore, and in some of the Himalayan granites. Mallet (**1159**—1, 168) has noted their occurrence in albite granite at WANGTU BRIDGE (31° 32′ : 78° 4′), and for some miles above that place in the valleys of the Sutlej and Wangar rivers; and La Touche (**1034**—14, 65) found large crystals in a vein of granite 4 miles to the W. of MACHEL (33° 25′ : 76° 24′) in Kashmir. In all these cases the mineral is of poor colour and merely translucent, so that it is of no value as a gem-stone.

BIHAR AND ORISSA.

Hazaribagh.—Small crystals of yellow **beryl** are abundant, according to Mallet (**1159**—7, 43), in a large dyke crossing the Tendwaha stream south of MAHABAR HILL (24° 43′ : 85° 50′) in the northern part of the district.

BURMA.

Mason (**1185**—1, 28) states that **beryls** are found in the sands of the Irrawaddy, and suggests that they might also be found in the streams descending from the granite hills to the east (**B.** 521).

MADRAS.

Coimbatore.—PADYUR or PATTALAI (11° 3′ 30″ : 77° 33′). The earliest account of the **beryl** mines at this locality was given in 1822

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by Leschenault de la Tour (**1062**—2, 262), who visited them when they were being worked by Mr. J. M. Heath, afterwards Manager of the Porto Novo Ironworks. In 1840, when the mines were described by Newbold (**1294**—22; —45, 772), they had been abandoned for some years, all the easily accessible material having been worked out. The mines have also been described by Walhouse (**1867**—1). The gems were found lining cavities formed by interlacing crystals of clevelandite, one of the accessory minerals in a vein of porphyritic granite or pegmatite, intrusive along the contact of gneiss with mica schists. They were of the clear blue or sea-green variety known as **aquamarine**. Nicholson (**1302**, 23) states that in 1819-20 the mine yielded 2,196 stones weighing 22 lbs., and valued at £1,210 (**B.** 520).

MYSORE.

Mysore.—Sambasiva Iyer (**1548**—11, 42) mentions the occurrence of pale yellow-green and bluish-green **beryls** in veins of pegmatite near the tank *bund* at MELKOTE (12° 40′ : 76° 42′ 30″), and to the S. of CHETTANHALLI, 4 miles to the S. of Melkote.

RAJPUTANA.

Ajmer.—Small rolled fragments of green **beryl** used to be found, according to Irvine (**910**—1, 160), among the Sora hills near RAJMAHAL (25° 54′ : 75° 32′) on the Banas R. (**B.** 521).

Kishangarh.—**Aquamarines** are mentioned in the Review of mineral production for 1909-13 (**862**, 270) as occurring at SAGAR, near SARWAR (26° 4′ : 75° 4′).

CHRYSOBERYL.

MADRAS.

Coimbatore.—Platy crystals of **chrysoberyl** have been found in corundum-bearing felspar veins near KANGAYAM (11° 0′ : 77° 37′), associated with nepheline-syenites; but are too highly flawed to be suitable for gems (**862**, 270).

RAJPUTANA.

Kishangarh.—Yellow crystals of good quality are said to occur with mica and aquamarines in pegmatite veins at GOVINDSAGAR (**862**, 270).

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CHRYSOLITE.

AFGHANISTAN.

Griesbach (**708**—4, 52) mentions the occurrence, in a dense variety of basalt forming hills about 3 miles to the N. of KANDAHAR, of bright green and yellowish crystals of **olivine**, which are used for making beads for rosaries and articles of jewellery.

CHRYSOTILE.

A serpentinous variety of the basalt of Kandahar contains veins and lumps of **chrysotile**, used for the more inferior kinds of beads for rosaries (Griesbach, **708**—4, 52).

DIAMOND.

The earliest account of the diamond fields of India, derived from personal observation, was given by Tavernier, whose voyages (**1747**) were originally published in 1665-69, though mention of a trade in Indian diamonds dates back to the time of Ptolemy. Another account, in which several localities not mentioned by Tavernier are included, was communicated to the Royal Society in 1677 by Henry Howard (**875**), Earl Marshal of England, afterwards Duke of Norfolk. In a series of papers published in 1880-81 (71—42; —44; —47; —48; —49; —50), Ball has thoroughly discussed the identification of the localities mentioned by these early writers, and in 1889 he brought out a re-translation of Tavernier's work, giving the results of his researches in an Appendix (71—67, Vol. II, 450-461). Information of a general character, dealing especially with the distribution of the diamond in Southern India, has also been given by Heyne (**834**—2, 92), Ritter (**1489**—2, Pt. VI, 343), and Newbold (**1294**—29, 22).

The diamond-fields of India are grouped in three distinct areas, in each of which the gems are associated with rocks of pre-Cambrian age, known as the Kurnool series in Southern India, and as the Vindhyan system in the north. In the Southern tract, comprising the districts of Anantapur, Bellary, Cuddapah, Kurnool, Kistna, and Godavari, the workings are mainly alluvial; but diamonds are also obtained from a band of conglomerate occurring at the base of the Kurnool series. The Eastern tract occupies a portion of the valley of the Mahanadi in Bihar and Orissa, with an extension westwards into the Central Provinces, and an outlying area to the north in the valley of the Koel, a tributary of the Son. In this tract the workings are entirely alluvial. The third or Central

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Indian tract is closely connected with the outcrop of a band of conglomerate lying between the lower and middle divisions of the Vindhyan system, extending for a distance of about 60 miles, with the State of Panna in Bundelkhand in the centre. Here the diamonds are obtained partly from the alluvium and rainwash derived from the conglomerate, and partly from the conglomerate itself. The mines of this tract are not mentioned by Tavernier or other early writers, and it seems probable that their discovery may be of more recent date than that of the diamond fields of southern India.

Compared with its former extent and importance, the diamond industry of India at the present time is of very limited proportions. The average annual production of the mines in the Madras Presidency, during the five years 1909 to 1913, was 38·36 carats, valued at £19; and in Central India, during the same period, 45·94 carats, valued at £853. In 1914 and 1915 no production was reported from Madras; but in the former year 54·65 carats, valued at £791, were produced in Central India, and in the latter 35·99 carats, valued at £603.

BIHAR AND ORISSA.

Kalahandi.—Minute diamonds were detected by Walker (**1872**—3, 21) in sands from the streams near BONDESOR (19° 54′ : 83° 14′). Though too small to be of value, others of larger size might be found by careful search. The sands have been derived from garnet-sillimanite (khondalite) schists.

Palamau.—SANKH R. (23° 16′ : 84° 17′). Blochman quotes a passage from the *Tuzuk-i-Jahangiri*, which is believed to refer to a forgotten diamond field lying near the source of the 'Sunk' R., to the south of the watershed of the Koel. Diamonds of considerable value are said to have come from these workings, but Hewitt (**833**, 418) says that none have been found for many years (**B.** 24).

SIMAH (23° 35′ : 84° 21′). Ball identifies this locality with the Soumelpour of Tavernier (**1747**, Vol. I, Pt. 2, 139; **71**—67, Vol. II, 81), who states that towards the end of the dry season about 8,000 persons were employed in washing the sands of the Koel R. for diamonds. Likely places in the bed of the river, indicated by the presence of 'thunder stones' (? ferruginous concretions) were surrounded by a temporary dam, and the sand and gravel when dry was excavated to a depth of not more than 2 ft., and carried to a shallow tank previously prepared on the bank, where it was broken up and thoroughly washed. The gravel was then spread out and searched for gems. Large stones were rarely found (**B.** 27).

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Sambalpur.—HIRA KHUND (21° 32′ : 83° 56′). The diamond fields of Sambalpur were visited for the first time in 1766, when Lord Clive commissioned a Mr. Motte to ascertain whether diamonds could be purchased on the spot for the purpose of making remittances to England. The account of this journey, which appears to have met with little success, was published in 1800 (**1262**).

According to the information then obtained, the diamonds were found in a red gravelly earth collected from the bed of the Hebe (Ib) R., which joins the Mahanadi a few miles above Sambalpur. Breton (**192**—1, 262; —2) and Kittoe (**994**—5, 375), writing in 1825 and 1839 respectively, also mention the Ib and other northern tributaries of the Mahanadi as far as up as the Mand R. as the source of the gems; but Ouseley (**1349**—3) and Voysey (**1853**—7, 859), at about the same period, describe the washings for gold and diamonds as being carried on at Hira Khund, an island situated about 4 miles below the mouth of the Ib R.; and Ball in 1877 (**77**—28, 186) was informed that the diamonds were only to be found in the bed of the Mahanadi itself. He thought it most probable that they had been originally derived from the Vindhyan rocks of the Barapahar hills, which lie to the south of the river.

The following account of the method of search is condensed from that given to Ball by one of the old diamond washers:—In the month of March, when the water was at its lowest, a temporary dam was thrown across the northern branch of the river at the head of the island, thus diverting the stream into the southern channel. The sand and gravel accumulated between the rocks in the bed of the river was then collected and washed in wooden trays, any gold that was found becoming the perquisite of the washers. No diamonds had then been found for many years, but from a list given by Breton (**192**—1, 273) it appears that, between the years 1804 and 1818, twenty stones were obtained, of which the largest, weighing 672 grains, was found in 1809 (**B.** 30).

CENTRAL INDIA AGENCY.

The diamond fields of Central India are situated along the northern scarp of the upper Vindhyan rocks which cover a large area in southern Bundelkhand; the gems being derived from bands of conglomerate occurring in the middle (Rewah) division of that series. During the last hundred years no change has been made in the primitive methods employed in the search for the gems, which have been described by the following writers:—

1819. Buchanan-Hamilton (**222**—2).
1822. Adam (**7**—2, 32).

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1829. Franklin (**616**—4).
1830. Jacquemont (**926**—3, Vol. I, 399).
1842. Adam (**7**—4, 399).
1860. Medlicott (**1197**—2, 65).
1875. Rousselet (**1522**, 440).
1881. Ball (**71**—45, 39).
1906. Vredenburg (**1854**—18).

The principal diamond-bearing layer occurs at the base of the Rewah shales, but according to Vredenburg, there is reason to believe that, in certain localities, a second layer exists at a higher horizon, *viz.*, at the top of the Rewah division, though it has not yet been detected *in situ*. The main layer consists of a thin band of indurated sandy conglomerate, locally known as *mudda*, resting directly upon Kaimur sandstone. From this the pebbles occasionally extend upwards, forming discontinuous bands of shaly conglomerate, known as *kakra*, which also contain diamonds. The pebbles associated with the diamonds are chiefly vein quartz from the granitic area of Bundelkhand; jasper from the Bijawar series; and a peculiar green quartzite (*kansiya*) derived from the lower Vindhyans, which is said, when it occurs in quantity, to be a favourable indication of the presence of the gems.

Three types of workings are distinguished by Vredenburg. (1) 'Direct workings,' in which the undisturbed conglomerate is reached by wide shafts, sometimes over 50 ft. in depth. These are sunk at the beginning of each working season, and are usually abandoned and allowed to fall in when the diamondiferous material within reach has been extracted. (2) 'Shallow workings,' situated on patches of the conglomerate which have been laid bare by the comparatively rapid denudation of the overlying shales. In these the material has become disintegrated to a certain extent by the action of the weather, and is thus more easily handled. (3) 'Alluvial workings,' situated along the banks of the streams that cross the outcrop of the conglomerate. Here the material has been sorted by the action of running water, and the heavier gravels containing the diamonds must be reached by pits, often as much as 30 ft. in depth.

The indurated *mudda* is broken up and well pounded with sledge hammers in shallow pits, in order to prevent the loss of flying fragments, and with the shaly *kakra*, which requires no preliminary treatment, is freed from clay and sand by thorough washing. The washed gravel is then spread out on a cleared space of ground, and repeatedly searched for diamonds. No mechanical device for sifting or grading the material is employed.

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The advantages of conducting the operations on a more systematic plan, and with modern appliances, have been fully discussed by Vredenburg. The undisturbed conglomerate, he points out, might be continuously worked after the manner of a coal seam; while the present wasteful method of working the 'shallow' deposits might be replaced by a regular system of trenching, of which full details are given in his report. After careful enquiry, he has estimated the minimum value of the deposits at 12 annas (=1 shilling) per square foot.

The following list of localities at which workings are now being carried on is extracted from that given by Vredenburg (**1854**—18, 286) :—

N. B.—**D** signifies 'Direct', **S** 'Shallow', and **A** 'Alluvial' workings.

I. Workings connected with the older conglomerate.

Bijawar State.—Simra, **S** (24° 46′ : 80° 18′).

Charkari State .
- Bajaria, **A** (24° 45′: 80° 19′).
- Khameria, **D**; Patti, **A** (24° 47′ 30″ : 80° 23′).
- Ranipur, **A** (24° 46′ 30″ : 80° 18′ 30″).

Chobpur State .
- Dia, **S** (24° 51′ 30″ : 80° 38′).
- Jhanda, **A** (24° 53′ : 80° 38′).
- Seha, **A** (24° 54′ : 80° 33′ 30″).

Panna State .
- Babupur, **A** (24° 48′ : 80° 23′ 30″).
- Bandi, **S** (24° 43′ : 80° 8′).
- Birjpur, **A** and **S** (24° 49′ : 80° 30′).
- Itwa, **A** (24° 47′ : 80° 26′ 30″).
- Kodaia group (24° 47′ : 80° 15′). Bara Manakpur, **S**; Chhota Manakpur, **A.**
- Majgama, **A** (24° 38′ 30″ : 80° 6′ 30″).
- Maraia, **S** (24° 42′ : 80° 9′).
- Panna group (24° 43′ : 80° 15′). Bhowanipur, **S**; Chunha, **D**; Harduapur, **S**; Ogra, **S**; Old Panna, **A**; Shahidan, **D**; Srinagar, **S.**
- Ranj R. group (24° 48′ : 80° 19′ 30″). Ganeshpur, **A**; Kalianpur, **D**; Radhanpur, **A.**

Patarkechar State.
- Banari, **A** (24° 56′ : 80° 39′ 30″).
- Majgawan, **S** (24° 55′ : 80° 52′).

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II. Workings connected with the newer conglomerate.

Kothi State . { JHANDA, **S** (24° 48′ : 80° 45′ 30″).
NAIGAWA (NEAGAON), **A** (24° 46′ 30″ : 80° 52′).

Panna State . { DURGAPUR, **S** (24° 42′ : 80° 33′).
MOHRA, **S** (24° 43′ : 80° 29′).
SAKERIYA, **S** (24° 39′ : 80° 20′).
SINGHPUR, **S** (24° 45′ 30″ : 80° 38′).
TINDINI, **S** (24° 41′ : 80° 26′).
UDESNA (MAHARAJPUR), **A** (24° 40′ 30″ : 80° 19′ 30″).

The production of diamonds from these mines has considerably declined during the last ten years. In 1904 it was 286·48 carats, valued at £2,636, and for the five years 1904 to 1908 the average annual output was 306·71 carats, valued at £2,799. In 1914 the production was only 54·65 carats, valued at £791; the average for the preceding five years having been 45·94 carats, valued at £853. In 1915 it declined still further, to 35·99 carats, valued at £603.

CENTRAL PROVINCES.

Chanda.—WAIRAGARH (20° 26′ : 80° 9′). The identity of these mines with those of Beiragarh, mentioned by Abdul Fazl in the '*Ain-i-Akbari*,' is fully established, according to Ball (**71**—45, 37). They appear to have enjoyed a considerable reputation, but Jenkins (**941**—1, 14) says that in his time (1827) the returns were insufficient to make them worth working; while Wilkinson (**1933**) and Malcolmson (**1158**—10, 250), writing in 1843, merely mention traces of the old workings, which had then been abandoned. The material in which the gems occur is stated by Hislop and Hunter (**843**, 355) to consist of lateritic grit. The source of the diamonds is not precisely known, but Ball considers it probable that they have been derived from an extension of the Kurnool or Lower Vindhyan rocks of the Mahanadi basin into this area.

MADRAS.

Anantapur.—WAJRA KARUR (15° 2′ : 77° 27′). Considerable interest was aroused, about the year 1880, by the discovery near this place of a volcanic 'neck' filled with decomposed basic rock bearing a striking resemblance to the matrix of the diamonds at Kimberley in South Africa. The occurrence was fully investigated and described by Foote (**596**—31, 109; —36), and the petrological characters of the rock forming the 'neck' by Lake (**1025**—3), who found that it consists of a highly altered plagioclase-augite

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rock, but that it is not serpentinous, like the Kimberley 'blue ground.' In 1884-85 the 'neck' was deeply prospected by Mr. A. Copley on behalf of a Madras Syndicate, but the operations met with no success. Occasionally, however, especially after a fall of rain, diamonds are found on the surface of the ground to the eastward of the village, but not in the neighbourhood of the 'neck.' Foote mentions a diamond from this locality, valued at £10,000, in the possession of Mr. R. S. Orr, of Madras.

The assertion made by Chaper (**301**, 1—3) that he had discovered the source of the Wajra Karur diamonds in a vein of epidote-bearing pegmatite intrusive in granulite, at some unspecified locality to the E. of the village, is not accepted by Foote. The gems, with which rubies and sapphires are said to have been associated, were not found actually in the pegmatite, but only in the immediate neighbourhood of the veins; and there is no reason to suppose that the association may not be fortuitous. Foote thinks it probable that the gems have been derived from a former extension into this area of the diamond-bearing conglomerate of Banganapalle in Kurnool (*see below*).

Bellary.—Huvin Hadagalli (15° 1′ 30″: 76° 0′). Foote (**596**—36, 43) mentions the occurrence, about 3 miles to the S. of the village, of a number of small pits and sorting platforms, which he suggests may be the relics of old diamond workings. The pits are situated on a layer of conglomerate which forms a part of the Dambal-Chiknayakanhalli band of Dharwar rocks. No record exists of any discovery of diamonds at this place.

Cuddapah.—Chennur (14° 34′: 78° 52′). An account of these mines is given by Gribble in the Cuddapah Manual (**707**—1, 24). Diamonds were formerly obtained from a bed of gravel lying at about 6 ft. below the surface, but the mines had been deserted since the beginning of the century. An attempt made in 1869 to work the mines did not prove successful; though there is a tradition, mentioned by King (**987**—7, 266), that two stones, eventually sold for £5,000 and £3,000 respectively, had come from this field (**B.** 9).

Kanuparti or Kondapetta (14° 33′ 30″: 78° 52′ 30″). This locality lies on the left bank of the Pennair R., opposite to Chennur. The mines were visited at the close of the eighteenth century by Heyne (**834**—2, 95), and again about the year 1840 by Newbold (**1294**—29, 226), who has given a full description of them, and of the methods employed in the search for diamonds. The excavations cover an area of more than a square mile. The diamonds

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are found in a bed of gravel, composed mainly of quartz, chert, and jasper pebbles, lying beneath from 4 to 12 feet of cotton soil. The gravel is carefully washed in small reservoirs raised on mounds and paved with stones, and is then spread out on a clear space at the foot of the mound and thoroughly searched. The diamonds are easily recognised when in a moist state by their lustre. In former times large stones are said to have been found here, but in recent years, except in 1834, the operations had not been profitable (**B.** 9).

The mines at OVALAMPALLI or WOBLAPALLI, mentioned by Heyne (**834**—2, 98), Voysey (**1853**—3, 127), and Newbold (**1294**—13, 125; —29, 226), are close to Kanuparti, and of the same description. Heyne says that this tract had been discovered about 40 years before the time of his visit, and that stones of considerable value had been found in it. Newbold mentions a diamond, sold for Rs. 1,450, which was found here in 1839.

GURAPUR, close to Chennur, HUSSANAPUR or DUPAUD, and JAMALADUGU or GULAGUNTA (14° 51′: 78° 26′) are localities mentioned in the District Manual; and LAMDUR and PINCHETGAPADU, to the W. of Chennur, but not marked on the map, are mentioned by Heyne and Newbold (**B.** 11).

Godavari.—BHADRACHALAM (17° 40′: 80° 57′). Both Voysey (**1853**—3, 125) and Newbold (**1294**—29, 233) say that diamonds are sometimes found in the bed of the Godavari, near the town, but give no further particulars (**B.** 24).

Guntur.—KOLLUR (16° 43′: 80° 5′). This locality is identified by Ball with the 'Coulour' of Tavernier (**1747**, Vol. I, Pt. 2, 137; **71**—67, Vol. II, 72), and Quolure of the account published in the Philosophical Transactions (**875**, 908). When visited by Tavernier in the year 1645, the mines were very productive, close upon 60,000 persons, according to his account, being engaged in the operations. They were situated on the right bank of the Kistna, between the river and a range of high mountains. The pits were from 12 to 14 ft. deep, but were not carried below the level of the subsoil water. The material excavated, a gravelly or sandy clay, after being steeped in water for a day or two, was thoroughly dried and freed from the clay by winnowing. It was then spread out in a thin layer and well pounded with heavy wooden pestles, and again winnowed until quite clean. Small quantities at a time were then spread out on the winnowing van, and searched for diamonds.

The great Mogul diamond, presented by Mir Jumla to the Emperor Shah Jehan in 1656, is said by Tavernier to have been

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found here. In its rough state it weighed 900 *ratis* or 787½ carats, but in the process of cutting it was reduced to 280 carats. Ball (**71**—67, Vol. II, 431), after an exhaustive discussion of the history of the stone, has concluded that, after a certain portion of it had been lost by mutilation, it was brought in 1849 to England as the Koh-i-Nur (*see also* Maskelyne, **1184**—1; —7; Ball, **71**—68;—69; Beveridge, **120**—2).

This diamond tract is said to have become almost exhausted by the year 1677 (**875**, 908), and it has long been deserted (**B.** 16).

MADAGULA (16° 30′ : 79° 38′). Ball identifies this place with Maddemurg, mentioned in the Phil. Transactions (**875**, 911). It is said that these mines were the most productive of any in the district, but that they were abandoned on account of the unhealthiness of the locality. An excellent account of the method of searching for the gems is given in the same paper.

MALAVARAM (16° 36′ : 79° 31′ 30″) or DAMARAPAD. Ball (**71**—45, 16) mentions some deserted diamond pits here, and suggests that they are the workings alluded to by Tavernier (**1747**, Vol. I, Pt. 2, 138; **71**—67, Vol. II, 78) as being situated between Kollur and Ramulkota. The mines, he says, though producing diamonds of fine water, had been closed on account of their brittle quality.

PULICHINTA, mentioned by Voysey (**1853**—6, 403) is situated on the right bank of the Kistna R., a few miles below Kollur.

Kistna.—The diamond tracts of this district are all situated within a short distance of the left bank of the Kistna R., between Bezwada and the frontier of the Nizam's territory. Voysey (**1853**—3; —6, 403) writing in 1825, has given a general description of the mines, and Mackenzie, in the Kistna Manual (**1130**, 244), has also compiled a general account, written mainly from a historical point of view.

The workings are all of an alluvial character, the gems being found in sub-recent gravelly deposits, derived either from rocks belonging to the Kurnool series forming hills lying to the north of the diamond fields, or from the Golapilli sandstones, a formation of Upper Gondwana age, consisting in part of the debris of the Kurnool rocks. The localities may be considered as forming three distinct groups :—

(1) GOLAPILLI (16° 43′ : 80° 58′), with MALAVILLI or MULELI. A full description of the Golapilli diggings in 1679, by Streynsham Master, is quoted in the Kistna Manual (**1130**, 146). The author considers that the diamonds found barely repay the cost of working the mines. The operations, which are well described, are carried

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on in the same manner as at Kollur in Guntur. Blanford (**148**—30, 27), writing in 1872, says that the mines had not been worked for more than 60 years, and that the gems were probably found in lateritic gravels derived from the Golapilli sandstones.

The Malavilli mines have been mentioned or described by Heyne (**834**—2, 92), Anderson (**28**), Benza (**110**—4, 47), Newbold (**1294**—32, 985), and King (**987**—18, 253). They are said to have been discovered about the year 1670 (**875**, 912), and to have produced well shaped and large stones, but apt to flaw when cut. Anderson gives a section of the deposits, and says that the diamond-bearing layer lies at a depth of 36 ft.; but the pits seen by Benza were not more than 12 ft. deep. According to King, the diamonds were sought for both in the Golapilli and overlying Rajamahendri sandstones forming the hills to the north of the village, and in alluvial gravels at the base of the range (**B.** 23).

(2) PARTIAL (16° 39′ : 80° 28′), with ATKUR, BARTHENIPADU, MUGALUR, and MUNALUR. The mines at Partial have been described by Scott (**1602**), Macpherson (**1150**—1, 118), Voysey (**1853**—7, 291), and Walker (**1868**—5, 184). According to Scott, the diamonds were found in a stratum of earthy gravel, of a yellowish or reddish colour, lying at a depth of from 14 to 30 ft. below the surface. His description of the operations agrees with that of Tavernier with regard to Kollur, except that no women were allowed to approach the workings. At the time of Voysey's visit, in 1825, the work consisted mainly in searching the old rubbish heaps, and the diamonds found were very small; but he thought that a considerable portion of the deposit still remained intact. Walker, however, writing in 1850, says that the gravels had practically been exhausted (**B.** 23).

The remaining tracts mentioned above lie in the immediate neighbourhood of the Partial workings, and are of the same description.

(3) USTAPALLI (16° 42′ : 80° 13′), with KODAVATAKALLU. These tracts are situated in the angle between the Muniair and Kistna rivers. No detailed account of the workings has been published, but they are of the same description as those of the Partial group. Heyne (**834**—2, 94) mentions a tradition that, when first discovered, the mines at Kodavatakallu produced several bullock loads of diamonds (**B.** 22).

Kurnool.—Old diamond workings are widely distributed in this district, which has given its name to the formation containing the original band of conglomerate from which most of the diamonds of

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southern India have been derived. A general account, including the history of the industry, has been given by Gopalakristnamah Chetty in the Kurnool Manual (**675**, 94), compiled in 1886, when the annual rent of the mines did not exceed Rs. 50. In recent years very few diamonds have been found, the average annual production during 1909 to 1913 having been only 38·36 carats, valued at £19.

The existence of diamond workings has been recorded at the following localities. Many of the names are taken from a list given by King (**987**—7, 106) on the authority of Captain J. G. Russel, Assistant Commissioner of Kurnool:—

BANGANAPALLE (15° 19′ : 78° 17′). The conditions under which diamonds occur *in situ* at Banganapalle have been carefully examined and described by King (**987**—7, 96). The diamond-bearing layer forms the basement bed of a band of quartzites, from 20 to 30 ft. in thickness, which constitutes the lowest member of the Kurnool series. This band of quartzite, near Banganapalle, has been uncovered over a wide area by the denudation of the overlying rocks, and now extends as a sheet or capping over the surface of the hills to the west of the town, resting unconformably upon a denuded platform of the older and more highly inclined Cuddapah beds. The productive layer consists of shaly breccia and conglomerate or pebbly clay, occurring in seams of 6 to 8 inches in thickness, and is reached by shafts, seldom more than 15 ft. in depth, from the bottom of which galleries are driven along the pebbly seams. In 1872, when this account was written, only the slopes near the town had been largely worked, the plateau beyond remaining almost untouched. The material excavated is broken up and pounded, washed free from clay, sifted, and laid out to dry on prepared floors. The clean sand is then examined in the hand by women and children. The diamonds found are very small, much flawed, and of poor colour.

Descriptions of the mines at this locality, in the earlier years of the century, were given by Heyne (**834**—2, 102), Voysey (**1853**—3), Malcolmson (**1158**—2, 78), and Newbold (**1294**—8, 120). These accounts agree in essential particulars with that given by King (**B.** 13).

BANNUR, close to GUDIPAUD.

BASWAPUR (15° 24′ 30″ : 78° 41′ 30″). Described by Newbold (**1294**—49, 390) and King (**987**—4, 71; —7, 103). The workings cover an area of about 2 sq. miles and are mainly alluvial, though King found traces in the neighbourhood of the Banganapalle quartzites, which had evidently been broken up by the old miners.

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BYANPALLI,=GURUMANKONDA. Rock workings.

COOMROLI, close to GURUMANKONDA. Called Cummerwillee in the Phil. Transactions (**875,** 913), where it is said that the stones obtained are very small.

DEOMURRU (15° 49′ 30″ : 78° 11′).

DEVANUR (15° 43′ 30″ : 78° 19′).

DHONI (15° 23′ 30″ : 77° 56′). Old alluvial workings are mentioned by Newbold (**1294**—51, 478). In the Phil. Transactions (**875,** 913) this place is said to afford stones of good shape and size, but of weak water.

GAZERPILLI, close to BASWAPUR. Produces stones similar to those at Dhoni.

GUDIPAUD (15° 44′ : 78° 18′).

GURUMANKONDA (GOTTIMANIKONDA, 15° 32′ : 78° 14′). Old rock workings.

KANNAMADAKALU (15° 42′ : 78° 15′). Old alluvial workings.

LANJAPOLUR (15° 45′ 30″ : 78° 4′). The stones found here are generally well shaped and of good water. They occur in a yellowish soil (**875,** 913).

MUNIMADAGU (15° 16′ : 78° 2′) with MADAVARAM. The old workings here have been described by Newbold (**1294**—29, 230) and King (**987**—7, 103). They are situated on outlying patches of the Banganapalle conglomerate, which have probably been worked out. In the Bellary Manual (**975,** 96), compiled in 1872, Kelsall states that the mines are only spasmodically worked, and that no revenue had been paid on them since the year 1813. During the previous ten years only 7 stones weighing more than a pagoda (52·56 grs., or about 16 carats) had been found (**B.** 11).

MURAVAKONDA (16° 1′ : 78° 19′). Diamonds are occasionally found in the bed of the Kistna R. at this locality, below the ford.

ORUVAKAL (VORAVAKOLLU, 15° 41′ : 78° 14′). ? WORKULL of Phil. Transactions (**875,** 913). Said to produce very small stones.

PANCHALINGALA (15° 52′ : 78° 5′).

POLUR (15° 32′ : 78° 29′ 30″).

PYAPALLI (15° 14′ : 77° 48′).

RAMULKOTA (15° 34′ : 78° 3′ 30″). Ball has identified this locality with Tavernier's Raolconda (**1747,** Vol. I, Pt. 2, 134; **71**—67, Vol. II, 53). In the Phil. Transactions (**875,** 913) it is called Ramulconeta, and is said to produce small stones, but of an excellent water. Tavernier says that the diamonds occur with sand or earth filling narrow veins in the rocks. The miners use iron crooks to extract the earth, which is washed and searched

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in the usual way. The diamonds are of fine water, but many are split in breaking up the rock in order to reach the veins. When Newbold visited the mines in 1840 (**1294**—15, 47; —29, 231), the only workings were in the debris lying at the foot of the slopes, though the remains of numerous and extensive mines in the solid rock were visible. The diamonds found in the detritus were of inferior quality. King (**987**—7, 105) also gives a brief account of these mines (**B.** 14).

SAITANKOTA (?)
TANDRAPAD (15° 51′ : 78° 7′). } Mentioned by Newbold (**1294**—29, 232).

TIMAPURAM (15° 32′ : 78° 7′). Rock workings. Still worked in 1872.

VIRAYPALLE (?). Quantitative tests made by Mr. A. Ghose on a bed of conglomerate varying from 3 ins. to 2 ft. in thickness gave a yield of 1-5 to 1-2 carat per 16 cub. ft. Most of the diamonds obtained were perfect crystals of fine quality and free from flaws (**862**, 83).

YEMBYE (15° 33′ 30″ : 78° 10′ 30″). Rock workings. Deserted.

PUNJAB.

Simla.—Some small diamonds, said to have been found in a hill stream near Simla, are preserved in the Geological Survey Museum, Calcutta. The find is mentioned in a letter to the *Times* of September 7th, 1872, but no details are given (**B.** 7).

GARNET.

BIHAR AND ORISSA.

Cuttack.—Garnets used formerly to be obtained from the sands of the Mahanadi R. by washing. Garnetiferous gneisses are very abundant in the province of Orissa (**B.** 522).

Hazaribagh.—A massive form of garnet, forming veins in metamorphic rocks, is found at several localities in the district, including the town of Hazaribagh itself. The mineral was described and analysed by Piddington (**1405**—38; —42), who gave it the name Calderite. An attempt was made about the year 1870 to place it on the market as an abrasive, but it did not prove remunerative (**B.** 523).

HYDERABAD.

Warangal.—GHARIBPET (17° 29′ 30″ : 80° 41′). Garnet mines at this locality were described in 1833 by Voysey (**1853**—6, 404). The rocks in the vicinity consist of highly garnetiferous granitoid

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gneiss, but precious garnets are said to be found only in the alluvial detritus, where, in Voysey's opinion, they are formed by the re-crystallisation of particles of garnet disseminated through the soil. Walker (**1868**—5, 186) says that they may be picked up in the watercourses draining the hills.

In 1913 the production of garnet in Hyderabad, presumably from this locality, amounted to 122 cwt., and an output of 115 cwt., is recorded in 1915. Formerly large quantities were sent to Madras to be made up into ornaments, but the industry has been in abeyance for many years (**B.** 522).

MADRAS.

Kistna.—KONDAPILLI (16° 37′ : 80° 36′). This locality has long been famous for its production of garnets. Crystals of regular form and perfectly pellucid are found, according to Heyne (**834**—2 252), in the sands near the town, also about Bezwada and along the banks of the Kistna. King (**987**—18, 264) says that the garnets are derived from bands of massive garnetiferous hornblendic gneiss among the hills in the neighbourhood (**B.** 522).

Nellore.—Newbold (**1294**—29, 224) remarks that red garnets are abundant in the crystalline and metalliferous rocks of the district. They are collected from the river sands and sold as a substitute for emery (**B.** 522).

One cwt. is returned as the output for this district in 1912.

Nilgiri.—Garnets resembling **essonite** or **cinnamon-stone** occur in large quantities, according to Benza (**110**—3, 266), at the crest of a knoll on the western side of the SEVEN CAIRNS HILL (? KONIBETTA, 11° 29′ : 76° 47′), 6 miles due north of Ootacamund. Portions of the rock are said to be almost exclusively composed of dodecahedral crystals of garnet with hornblende.

Salem.—SANKERIDRUG (11° 29′ : 77° 56′). Green garnets were found here by Newbold (**1294**—29, 225) in quartz veins penetrating hornblende schists, and associated with other green crystals, near intrusions of porphyritic granite. The garnets did not occur in large quantities. Fine crystals of red garnet abound in the crystalline and metalliferous rocks, as in Nellore, and are sold at an insignificant price. Dark brown **colophonite** is also widely distributed in the granites of these districts.

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Tinnevelly.—A large proportion of the stones contained in a parcel of gems collected by the villagers at MEL AMATHUR (9° 34′ : 77° 55′), and examined by Fermor (**577**—10), consisted of garnets. The specimens vary in colour from pink and brownish-pink to a beautiful deep red, and are often sufficiently clear and free from flaws to be used as cheap gems.

Over 1,000 tons of garnet sand for abrasive purposes are returned as having been collected in the district in 1914, but no output was recorded for the year 1915.

Travancore.—Garnets of small size, but very rich in colour, are exceedingly abundant, according to King (**987**—25, 89), in the sands of the sea shore.

Vizagapatam.—GALIKONDA (?GOLGONDA, 17° 41′ : 82° 32′) is especially mentioned in the Vizagapatam Manual (**285,** 154) as a locality where garnets are obtained (**B.** 522).

RAJPUTANA.

The most important garnet mines are situated along the outcrop of the Arvali schists, especially where these are traversed by granitic intrusions, between the States of Jaipur and Udaipur. In a brief account of the mines given by Hacket (**730**—4, 249) it is stated that all were then (1880) abandoned; but only ten years earlier Horst (**871,** 73) says that a large trade was being carried on between the mines and Delhi, and it is recorded that large revenues were formerly derived from the lease of the workings (**B.** 523).

In recent years the mines have been re-opened, and are now worked in the following districts :—

Ajmer.—The production of garnet in this district amounted in 1900 to 139 cwt., but since the year 1907 it has greatly declined, the average annual output for the five years 1909 to 1913 being only 12 cwt.

Jaipur.—RAJMAHAL (25° 53′ 30″ : 75° 31′ 30″). No statistics of the production of these mines in recent years are available.

Kishangarh.—SARWAR (26° 4′ : 75° 4′). These are the most important mines in the province, and are said to produce the finest garnets in India. The workings extend, according to Hacket (**730**—4, 249), for a distance of upwards of a mile along a narrow

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belt of schists. The average annual output for the five years 1909 to 1913 was 253 cwt., valued at £1,661. In 1914 the output was 464 cwt., valued at £4,333, but the mines were closed in 1915.

Mewar (Udaipur).—SHAHPURA (25° 37′ 30″ : 74° 59′). The mines mentioned by Hacket (**730—4**, 249) were situated at MAGA or MEJA, several miles to the S. W. of Shahpura. They produced 46 cwt., valued at £84, in 1913.

IOLITE, CORDIERITE, DICHROITE.

Iolite is found in the gem gravels of Ceylon and sold under the name of **lynx-** or **water-sapphire.** The following instances of its occurrence in India have been noted :—

MADRAS.

Travancore.—Cordierite has been detected by Chacko (**297**—2, 12) in a granite dyke near THIRUVELLA (TERUWULLA, 9° 23′ : 76° 37′). The mineral occurs in violet patches and spots, associated with monazite, magnetite or ilmenite, garnet, and biotite.

Trichinopoly.—Bose (*see* **861,** 248) has reported the occurrence of **iolite** in abundance near UDAIYAPATTI (10° 48′ : 78° 18′) and KIRANUR (10° 47′ : 78° 20′ 30″) in the Kadavur Zemindary, where it is associated with labradorite and mica schist. Old pits, apparently made in search of the mineral, were noticed.

Vizagapatam.—Microscopic crystals of **cordierite** have been recognised by Walker and Collins (**1873,** 13) as forming the most abundant constituent of certain sillimanite schists collected by Middlemiss in the Hill Tracts of Vizagapatam.

JASPER.

Pebbles of jasper of a great variety of tints occur in the rivers draining the areas occupied by the Dharwar and Bijawar formations, both of which contain numerous layers of banded jasper. Immensely thick beds of conglomerate, occurring in the Mahadeva group of the upper Gondwana system, consist largely of the debris of these older rocks, and furnish an abundant supply of jasper pebbles to the rivers which drain the Satpura range in the Central Provinces.

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BOMBAY.

Kathiawar.—According to Summers (**1726**—1, 319), green jasper with brilliant red streaks or spots, commonly known as **heliotrope** or **bloodstone**, is found near TANKARA (22° 40′ : 70° 48′ 30″), and is sold to the lapidaries of Cambay. It is said to occur in massive layers below the surface soil.

KYANITE.

Kyanite is a common constituent of the Archæan rocks in India, but is seldom used as a gem. It is also particularly abundant in the schists and granite of Bashahr in the Himalaya (Hayden, **793**—9, 102), where the crystals are sometimes of a deep blue colour, and are often mistaken for sapphires. Its occurrence has been specially recorded in the following instances :—

BIHAR AND ORISSA.

Manbhum.—The blue corundum of SALBANNI (23° 4′ : 86° 20′), already noted, is described by Warth (**1892**—23) as occurring in a vein of kyanite of a pale blue colour, varying in thickness from 2 to over 3 ft., and traced for a distance of about 6 miles.

HYDERABAD.

Warangal.—Crystals of kyanite are mentioned by Voysey (**1853**—6, 404) as occurring in abundance at the garnet mines of GHARIBPET (17° 29′ 30″ : 80° 41′).

MADRAS.

Coimbatore.—Middlemiss (**1219**—19, 40) mentions having found quantities of kyanite crystals among the debris of some pits, apparently made in search of corundum, near KANJIKOVIL (11° 22′ 30″ : 77° 39′ 30″). He thinks it possible that similar finds have given rise to the reports mentioned by Newbold (**1294**—38, 153) that sapphires are picked up in the valley of the Cauvery.

PUNJAB.

Patiala.—Bose (**173**—21, 59) has recorded an occurrence of kyanite associated with calcite, in the hills west of NARNAUL (28° 3′ : 76° 10′). It is said to be found in some quantity. The mineral is called *bruj* by the Patiala jewellers, and used by them as a gem.

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LAPIS LAZULI.

A report that lapis lazuli is said to have been found in the NAGPAHAR HILLS, 3 miles to the W. of Ajmer, is mentioned by Irvine (**910**—1, 162), but requires confirmation (**B.** 529).

Lapis lazuli was formerly imported to India from the mines of Firgamu in Badakshan, described by Wood (**1958**—2, 263) in the narrative of his journey to the source of the Oxus (**B.** 529).

ONYX.

BOMBAY.

Kathiawar.—Onyx is widely distributed, according to Adye (**11**, 107) over those parts of the State of Navanagar which are occupied by bedded lavas. It is most abundant about a mile to S. W. of the State bungalow at VIJARKHI (22° 25′ : 70° 14′ 30″); about 2 miles to E. of KHOKHRI (22° 23′ 30″ : 70° 28′); a mile and a half from BAOLIDAR (22° 9′ : 70° 13′ 30″) in the direction of Kharkhambalia; and half a mile to N. E. of BORI (22° 9′ 30″ : 70° 18′). A vein of onyx was observed at a spot three quarters of a mile to S. of NARMANA (22° 5′ : 70° 13′).

OPAL.

BOMBAY.

Ahmadnagar.—Numerous and very fine specimens of milk-white opal, with a flame coloured iridescence, are reported by Sykes (**1736**—1, 425) as being procured on the banks of the Sina R., between ANDARGAON (18° 2′ : 75° 38′ 30″) and PARANDA (18° 16′ : 75° 31′).

CENTRAL PROVINCES.

Nagpur.—Fermor (**577**—32, 214) mentions that opal is sometimes found filling cracks in the manganese ores. Good examples were met with at KANDRI (21° 25′ : 79° 20′) and KODEGAON (21° 25′ : 79° 1′).

HYDERABAD.

Opals are mentioned by Heyne (**834**—2, 264) as being found near Hyderabad city, with chalcedony, carnelian, and amethyst.

MADRAS.

Vizagapatam.—Opal is of common occurrence, according to Fermor (**577**—32, 214), in the manganese mines of the district, where it replaces the felspathic portion of kodurite (*see* **MANGANESE, Vizagapatam**). Good examples are to be found at KODUR (18° 16′ 30″ :

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83° 36′ 30″) and KOTAKARRA (18° 22′ 30″ : 83° 33′). It is also found at BOIRANI (19° 35′ : 84° 49′) in Ganjam.

RAJPUTANA.

Ajmer.—Irvine (**910**—1, 162) states that massive milk-white opal is found at the base of the hills near SRINAGAR (26° 26′ : 74° 50′).

ROCK-CRYSTAL *and* ROSE-QUARTZ.

BIHAR AND ORISSA.

Sambalpur.—Remarkably fine **rock-crystals** were noticed by Ball (**71**—28, 183) near the village of BIJKOMAR (20° 40′ 30″ : 83° 31′ 30″), apparently occurring in nests in vein quartz. Both the smoky and pellucid varieties are obtainable (**B.** 503).

BOMBAY.

Kathiawar.—Summers (**1726**—1, 318) states that the lapidaries of Cambay obtain their supply of **rock-crystal** from TANKARA (22° 40′ : 70° 48′ 30″) in Morvi, where it is found beneath the surface soil in pieces up to 20 lb. in weight.

CENTRAL PROVINCES.

Chhindwara.—KHAIRI (21° 32′: 78° 53′ 30″). A vein of **rose-quartz** was found by Fermor (**577**—6, 176) crossing the Khairi stream about three quarters of a mile to N. W. of the village. The vein is about 25 ft. wide, and the outcrop about 150 yds. in length. The colour varies from milk-white to pink and deep rose.

DUDHARA HILL (21° 30′ : 78° 57′). Fermor (*l. c.*) found blocks of **amethystine pink quartz** on the western slope of the hill. The outcrop of the vein was concealed by talus.

HYDERABAD.

Warangal.—Walker (**1868**—4, 223; —5, 187) states that **rose-quartz** is found near WARANGAL (17° 57′ : 79° 41′), and is common in other parts of Hyderabad territory. It is used for ring stones and other cheap jewellery (**B.** 503).

MADRAS.

Godavari.—Campbell (**272**—12, 282) says that large prisms of **rock-crystal** were formerly obtained in the bed of the Godavari near RAJAMAHENDRI (17° 0′ : 81° 50′).

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Tanjore.—VALLAM (10° 43′ : 79° 7′). Pebbles of **rock-crystal, smoky quartz,** and **cairngorm** are collected from the beds of streams traversing the grits of the Cuddalore sandstone series (King and Foote, **988,** 258, 370). Under the name of 'Vellum stones' these are cut by the lapidaries of Tanjore and Trichinopoly into a variety of ornamental and useful articles, including watch-glasses and spectacle lenses (**B.** 502).

Vizagapatam.—Veins of **rose-quartz** occur, according to Fermor (**577**—32, 212), in decomposed lithomargic rocks at KODUR (18° 16′ 30″: 83° 36′ 30″). Loose hexagonal crystals are also found in gravel deposits at SANDANANDAPURAM (18° 14′ : 83° 37′).

PUNJAB.

Delhi.—AURANGPUR (28° 27′ 30″ : 77° 19′). Hacket (**730**—250) says that **rock-crystals** were formerly obtained from a number of small pits, apparently sunk on a quartz vein running through the Delhi quartzites (**B.** 503).

Baden-Powell (**60**—1, 47) quotes an account of the mines by Dr. Thompson. The crystals are found in a secondary breccia cemented by oxide of iron, exposed in a small basin among the hills about 2 miles to the S. W. of the village. The best crystals were said to come from depths below 10ft., those nearer the surface being tinged with iron oxide.

Mianwali.—MARI (32° 57′ 30″ : 71° 39′). The occurrence of bi-pyramidal crystals of **quartz** in the red gypseous marls at Mari, Kalabagh and other localities in the neighbourhood has been noticed by Jameson (**931**—3, 206), Fleming (**591**—5, 251), Verchère (**1839**—2, 20), and Wynne (**1975**—18, 300). The crystals go by the name of '**Mari diamonds,**' and are collected and drilled to be made into necklaces (**B.** 503).

RUBY.

AFGHANISTAN.

The ruby mines of JAGDALLAK (34° 22′ : 69° 48′), described by Griesbach (**708**—21, 71), are situated at the crest of the Siah Koh range, about 5 miles to the W. of Kardeathal. The rubies occur as accessory minerals, with a few sapphires, large quantities of garnets, spinels, etc., in a belt of highly crystalline limestone, considered by Griesbach to be a sedimentary deposit of Carboniferous age, altered by granitic intrusions. In places the rubies are so numerous as to give a pink tinge to the rock, but these are usually

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very minute. There is no regular system of mining, but wherever the gems are visible on the weathered surface, the rock is quarried out, and the rubies extracted with hammer and chisel, many being broken or lost in the process.

The age of the ruby-bearing limestones has been discussed by Hayden (**793**—22, 11), who is inclined to refer them to the Archæan group.

BURMA.

The ruby mines of Upper Burma have long been known as the principal source of the world's supply of the gem. Cæsar Fredericke (**621**, 239), who visited Pegu in 1569, alludes to the brisk trade in rubies that was then carried on; and reference to the mines was also made about the same time (1586) by the English traveller Ralph Fitch (**589**, 262; **1538**, 172) who places them in the district of 'Caplan' (?Kyatpyin), five days' journey from Ava. Neither of these travellers was permitted to visit the mines, and the first authentic account of them was given in 1833 by Père Guiseppe d'Amato (**412**). He describes the workings at KYATPYIN (22° 53′ 30″: 96° 28′), and the system of mining practised by the Burmese, which may still be seen in operation in that neighbourhood (**B.** 427).

Three distinct ruby tracts are known to occur in Upper Burma, widely separated from each other; but in all cases the original source of the gems is found to be a highly crystalline limestone, probably a member of the Archæan group. A fourth tract is reported to have been discovered in the Momeik State in 1913, but as yet no definite information regarding this occurrence has been published.

Mandalay.—SAGYIN (22° 17′: 96° 7′). About the year 1870 these mines were in charge of a Mr. Bredemeyer, whose account of them (**191**) is referred to by Ball (**71**—45, 428). The locality was reported on by Hayden (*see* Griesbach, **708**—29, 9) in 1895. A group of hills, composed of crystalline limestone largely quarried for statuary marble, rises abruptly from the alluvial plain on the left bank of the Irrawaddy, about 16 miles to the N. of Mandalay. Moisture, acting along the joint planes of the rock, has caused it to become seamed with fissures and hollows, filled with the insoluble clayey material supplied by the disintegration of the limestone. These fissures are followed up and the material extracted from them is washed. Sapphires and spinels, as well as rubies, are obtained here. In recent years the working of these mines does not appear to have been attended with favourable results, and no returns of output have been furnished.

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Myitkyina.—NANIAZEIK (25° 37′ : 96° 37′). The ruby tract of Naniazeik was first brought to notice in 1895, when it was examined by Warth (*see* Griesbach, **708**—28, 152), who reported that rubies, sapphires, and spinels are obtained from the detritus afforded by the disintegration of crystalline limestones surrounded by intrusive masses of granite. A full description of the tract has since been given by Bleeck (**154**—2), and the petrology of the area has been studied by Tanatar (**1742**).

The limestones are considered by these authorities to have been originally calcareous sedimentary deposits, and to have been altered, while in a state of intense local compression due to orographic movements, by contact with the intrusive granite, with the production of corundum and other accessory minerals at those places where the pressure was most severe.

Neither ruby nor spinel appear to be very abundant in this tract and no output has been reported for the last twelve years.

Bleeck also mentions a small ruby tract, worked with poor results by the Kachins, on a hill stream 4 miles to the N. of MANWE (25° 26′ : 96° 35′), and some deserted ruby pits said to lie 13 miles to the N. W. of Naniazeik.

Ruby Mines.—MOGÔK (22° 55′ : 96° 33′). In this district the crystalline ruby limestones form a series of narrow, parallel, lenticular bands, distributed in echelon along the southern flanks of a range of hills extending from the neighbourhood of Mogôk, where the most productive mines are situated, to Thabeikkyin on the Irrawaddy, a distance of about 40 miles in a direct line from east to west. The workings, however, are confined to the eastern half of the calcareous zone, between SHWENYAUNGBIN (22° 55′ : 96° 19′) and MOGÔK, where the condition of the bands suggests that they have been subjected to a more intense degree of compression than further west, where rubies appear to be absent. (Their general alignment is shown on the map attached to Barrington Brown's paper in the *Philosophical Transactions*, noted below, and on the map of the Northern Shan States, Western Section in the *Memoirs, Geological Survey of India*, Vol. XXXIX, Pt. 2.)

The following accounts of the mines have been published since the district was thrown open by the annexation of Upper Burma in 1886 :—

1888. } Gordon { (**677**—4) } Popular accounts of the mines and
1889. } { (**677**—5) } their surroundings.

1889. Streeter (**1718**). Account of a visit to the mines, and of the native system of mining.

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1895. Barrington Brown and Judd (**208**). An exhaustive treatise on the geology and petrology of the district, with a discussion by Prof. Judd of the genesis of the corundum and of the minerals associated with it.

1896. Bauer (**88**—4). Describes the mode of occurrence of the ruby, and the petrology of the associated rocks and minerals.

1897. Wynne (**1978**). Notes on the geology of the area, and description of the European and native methods of working.

1904. Morgan (**1252**). Describes the operations of the Ruby Mines Co.

1909. Anon. (**35**—79). A brief account of the mines and their development.

1910. Goldschmidt and Schroeder (**672**). Describes the crystallographic characters of ruby from Burma.

1915. Claremont (**318**). A popular account of the operations of the Ruby Mines Co.

The native workings, as described by Barrington Brown and others, are of three kinds:—(*a*) *Loodwin*, in which fissures and hollows in the limestone, filled with detritus derived from its disintegration by weathering, are followed up and quarried. (*b*) *Hmyaudwin*, or cuttings driven into the rainwash on the hill slopes, covering the outcrop of the limestone; and (*c*) *Twinlone*, or pits sunk in the alluvial deposits spread over the floor of the valleys, in order to reach the gem-bearing gravel, called *byon*, which usually lies at a considerable depth. Small rubies are also obtained by washing the sand and gravel in the beds of the streams.

In 1889 a lease of the ruby tracts was granted to the Burma Ruby Mines Co. at an annual rent of Rs. 3,15,000 (subsequently reduced to Rs. 2,00,000) *plus* a share of the profits, together with the right to levy royalties on the output of native workings in the townships of Mogôk, Kyatpyin, and Katha. The operations of the Company have hitherto been confined to a systematic excavation of the alluvial deposits covering the floor of the Mogôk valley, which was apparently in former times occupied by a lake, and in washing the *byon* with the aid of the most modern appliances. Electric power is largely used for driving the machinery, and is obtained from a waterfall at the outlet of the valley.

In addition to rubies, the *byon* contains large quantities of spinel, usually of a brilliant red colour, and more rarely sapphires and crystals of blue apatite. Tourmaline is also common, but is of the black variety and of no value as a gem.

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The average annual output of **ruby, sapphire,** and **spinel,** during the five years 1909 to 1913, was 283,439 carats, valued at £63,272. In 1914 and 1915 respectively the amounts produced were :— Rubies, 193,333 carats, value £40,781, 167,904 carats, value £34,881, Sapphires, 56,709 carats, value £2,052, 39,718 carats, value £1,276; Spinels, 54,830 carats, value £300, 43,827 carats, value £141.

The crystalline limestones are considered by Judd to have resulted from the decomposition at great depths of the lime felspars contained in basic gneisses and granulites, with a subsequent concentration of the calcium carbonate along definite zones, and the inclusion of a portion of the alumina, derived from the aluminous silicates, in the form of corundum. A transitional stage was the formation of scapolite gneisses through the 'werneritisation' of the felspars in the original rock. The stratigraphical evidence, on the other hand, seems rather to point to the conclusions arrived at in the case of the similar occurrence of rubies, etc., at Naniazeik, *viz.*, that the limestones were originally calcareous sediments, and that they have been altered by contact with igneous intrusions, under conditions of great pressure.

MADRAS.

Salem.—Newbold (**1294**—29, 224) states that fine rubies have been found at several of the corundum mines in the district, particularly at VIRALIMODOS(?) in the Parmati Taluk, and at SHOLASIGAMANI (11° 15′ : 77° 56′) in the Trichingode Taluk (**B.** 422).

MYSORE.

Kadur.—Stones of some value, though not equal in colour to true rubies, are occasionally found, according to Evans (**555**—5) in the corundum pits at KADAMANE (13° 26′ 30″ : 75° 18′) near Sringeri.

SAPPHIRE.

BURMA.

The rubies of Upper Burma are invariably accompanied by sapphire, derived in the same manner from crystalline limestone. The proportion of blue corundum found in the gem gravels is usually much smaller than that of the red variety, though the stones are often of larger size. (For statistics of production, *see* **RUBY**).

KASHMIR.

Padar.—SOOMJAM (33° 25′ 30″ : 76° 28′). An accidental discovery of sapphires in considerable quantities in Kashmir was

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reported early in the year 1882. Some of the gems were in that year examined by Mallet (**1159**—33), who pronounced them to be true sapphires. They were then supposed to have come from the neighbourhood of Padam in Zangskar, but the approximate locality is correctly stated in a letter from the Rev. A. W. Heyde quoted in Mallet's paper, as on the southern slopes of the Zangskar range, below the Umasi La (pass). The exact position was subsequently ascertained to be in a small upland valley, 2,500 feet above the village of Soomjam, and at an altitude of about 14,000 ft. above the sea. The deposit is said to have been laid bare by a landslip.

In 1887, at the request of the Kashmir Durbar, the locality was examined and reported on by La Touche (**1034**—14). The sapphires were found to occur as accessory minerals, with tourmaline, garnet, kyanite, and euclase, in a vein of pegmatite intrusive in a series of rocks including biotite gneiss, lenticular masses of kupfferite, and crystalline limestone. The detritus from this vein had been spread over a portion of the valley below, and from this whole crystals of sapphire, with fragments and chips in considerable quantities, were obtained by washing. The ground is under snow for the greater part of the year, and work is only possible during the months of July, August, and September.

For some years the Durbar derived a considerable revenue from the mines, which were then abandoned under the impression that they had been worked out. But in 1906 work was re-started by the Kashmir Mineral Co., and at first several valuable stones were obtained, one of them being sold for £2,000. Very soon, however, the production fell off, and the mines have not been worked since 1908.

Shepard (**1618**—3) has discussed the mode of occurrence of the sapphires at this locality, as compared with those of Laurens Co., S. Carolina, and other places in the United States.

PUNJAB.

Kangra.—Calvert (**265**—2, 54) has reported that he found sapphires on the ascent to the HAMTA PASS (32° 16′ : 77° 26′) in Kulu, but no specimens appear to have been submitted to a competent authority, and the statement requires confirmation.

SPINEL.

AFGHANISTAN.

Spinels are said to occur abundantly in the ruby mines of JAGDALLAK, already noted under **RUBY.** As Medlicott pointed out

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in 1880 (**1197**—56, 4), many of the so-called rubies obtained at this locality are in reality spinels (**B.** 429).

BURMA.

Quantities of spinels are found at the same localities, and under the same conditions, as the rubies of Upper Burma, already noted above. (For statistics of production, *see* **RUBY.**)

Myitkyina.—Large numbers of spinels were found by Griesbach (**708**—22, 130) in the sands of the Irrawaddy above Myitkyina, especially at the village of WATU (25° 30′ : 97° 30′). They have also been reported to occur in quantity near the junction of the PUNGIN KHA and MALI KHA (25° 49′ : 97° 32′), above the Confluence.

TOURMALINE.

BURMA.

Karenni.—NAMÔN (19° 22′ : 97° 35′). At this locality, situated 13 miles to the N. of *Ywathit* on the Salween R., crystals of a beautiful dark emerald-green variety of tourmaline are found scattered through the surface soil, and are mined on a small scale. The occurrence has been described by Middlemiss (**1219**—22, 152). The matrix of the tourmaline was ascertained to be a white crystalline limestone, blocks of which are strewn over the hill slopes where the pits are situated. The stones are sent for sale to Rangoon, where for some time they possessed a fictitious value, due to their being successfully passed off as emeralds.

Mongmit.—MAINGNIN (23° 14′ : 96° 46′). George (**645**) has given an interesting account of the history and present condition of the **rubellite** mines situated about a mile E. of Maingnin, surrounding the Palaung village of Sanka. The mines are said to have been discovered and worked by Chinese some 150 to 200 years ago, but were deserted until 1869, when they were re-opened by some of the Kachin chiefs. The matrix of the tourmaline is described as a vein of white, hard, granitic rock, probably a vein of granite which has become decomposed through the kaolinisation of the felspars, which is covered by a considerable thickness of red surface soil. The white vein, called *kyaw*, is reached by square shafts, ordinarily from 60 to 75 feet in depth, and sometimes carried to about 100 feet. Each owner is allowed to extend his workings along the vein to a distance of 5 fathoms from the centre of the shaft. Attempts have been made to reach the vein

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by a simple process of hydraulic sluicing, but have not proved altogether remunerative, owing to a lack of water except in the rainy season.

On account of the extremely irregular distribution of the tourmaline in the veins, a successful venture is a matter of pure speculation. The tourmaline varies in colour from brown or black to a light transparent pink, which is the most highly prized variety. The gems are sold by weight, the pink variety, called *ahtet yay*, fetching from Rs. 1,200 to Rs. 1,500 per viss (3·65 lb.); while the inferior kinds, *ahka*, are sold for about a third of that price. No returns of output have been furnished since 1909, when it amounted to 5·1lb., valued at £36.

Ruby Mines.—During the four years 1904 to 1907, an average output of 101 lb. of **rubellite** per year was recorded; but no returns have been made in subsequent years. The tourmaline is obtained in the southern part of the district, under the same conditions as in Möng Lông (*see below*).

Shan States (N.).—The tourmaline mines of Möng Lông were visited and reported on by Noetling (**1311**—6) in 1891, and a brief description of them was given by Barrington Brown (**208**, 166, 185) in his account of the ruby mines of Mogôk. The workings are situated in the valley of the NAMPAI R., 2 or 3 miles to the N. of the town of MÖNG LÔNG or MAINGLÔN (22° 47′ 30″ : 96° 40′), in thick beds of gravelly detritus washed down from the hill slopes to the north of the valley. These hills are composed of gneiss, penetrated by broad veins of granite containing tourmaline as an accessory constituent. The gravels have been trenched in all directions in search of the gems, a rude system of hydraulic sluicing being employed. Though black tourmaline is common, crystals of the red variety are said to be rarely found, and the output fluctuates considerably from year to year. In 1908 thirty-two stones, valued at £289, and in 1909 seven stones, valued at £26, were found, but since the latter year no returns have been received.

KASHMIR.

Padar.—Crystals of light green tourmaline were found by La Touche (**1034**—14, 64), penetrating vein-quartz at a spot about a mile to the N. of the sapphire mines near SOOMJAM (33° 25′ 30″ : 76° 28′). The crystals were very thin in proportion to their length, and very brittle.

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TURQUOISE.

RAJPUTANA.

According to Irvine (**910**—1, 162), turquoise has been reported to occur in the Ajmer hills, and at RAMGARH (27° 15′ : 75° 14′ 30″) in Shekhawati; but the mineral referred to is probably a blue copper ore (**B.** 435).

The turquoise ornaments universally worn by women in the Himalaya, and used in a crushed state for mosaic work by the silversmiths of Kashmir, probably comes from the turquoise mines of Nishapur in Khorassan. These mines have been described by Griesbach (**708**—12, 62), Schindler (**1571**), and Tietze (**1786**—1). The turquoise occurs in trachytic breccias associated with limestones and volcanic ash beds. The chemical properties of the mineral have been discussed by Prinsep (**1436**—4), and Fischer (**585**).

ZIRCON.

MADRAS.

Coimbatore.—Zircon occurs in small quantities in nepheline syenites near KANGAYAM (11° 0′ : 77° 37′), but is not sufficiently transparent and flawless to be used as a gem (**862**, 274).

Travancore.—Masillamani (**1183**, 9) has recorded the occurrence of zircon in pegmatite veins associated with charnockites at APPIYODE (?8° 14′ : 77° 14′), in the Eraniel Taluk. In the weathered material derived from these rocks crystals from microscopic size up to two inches in length are met with. The colours are red or greyish white, but the crystals are seldom transparent, except in parts.

GLASS-MAKING MATERIALS.

An inferior kind of glass, used chiefly in making bangles, is manufactured in many parts of India from the alkaline efflorescence known as *reh* (*see under* SODA), when it occurs on a sandy soil; or, when sand is not present, by melting together *reh* and river sand or pounded quartz. Hitherto but few attempts have been made to find deposits of quartz sand suitable for the manufacture of glass of better quality, but the matter appears to be receiving attention. The prospects of establishing a glass-making industry in India were discussed by Alakh Dhari (**482**) in a paper read at the 2nd Indian Industrial Conference held in 1906.

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BIHAR AND ORISSA.

Santal Parganas.—An investigation was undertaken in 1908 by Murray Stuart (**1723**—1) in order to ascertain the suitability of certain sands in the Rajmahal hills for glass manufacture. Two kinds of sand were examined :—

(*a*) River sand from the Ganges and some of the hill streams. These were found to be contaminated with iron, mainly in the form of ferro-magnesian silicates, but they could be used for making cheap bottles.

(*b*) Bedded sandstones of the Damuda series, exposed in the Rajmahal coal fields. Samples from MANGAL HÁT (25° 4′ : 87° 51′) and PIR PAHAR (25° 6′ : 87° 50′) were examined. These are white gritty sandstones, and require crushing and sifting before being utilised. They contain about 6 per cent. of kaolin, which would need removal by washing. Perfectly clear lead-potash glass was made experimentally from these sands, but since it was found impossible to remove all traces of kaolin, even by prolonged washing, they would not be suitable for the manufacture of high grade flint glass. The supply is said to be unlimited.

CENTRAL INDIA AGENCY.

Gwalior.—Pounded quartz obtained from white quartz reefs traversing the Bundelkhand gneiss area, to the south of Gwalior, is used for glass making at the Morar Works (**1034**—39, 114).

CENTRAL PROVINCES.

Buldana.—LONAR (19° 59′ : 76° 34′). The soda obtained from the Lonar Lake was formerly used in considerable quantities for the manufacture of glass bangles. In 1856, according to Smith (**1658,** 3), there were two factories at work near the lake, and each man employed could turn out from 600 to 700 bangles a day. There is an abundant supply of crystalline quartz in the neighbourhood.

MYSORE.

Chitaldroog.—MATTOD (13° 46′ : 76° 28′) and MOLAKELMURU (14° 43′ : 76° 48′ 30″). Glass making has been carried on at these places for more than a century. The industry was noted in 1814 by Heyne (**834**—2, 354), and recently the process has beem described by Sambasiva Iyer (**1548**—7, 246). Quartz is obtained locally, and soda from efflorescent deposits at KENCHAMMANHALLI(?) in the Royadurga Taluk. The materials are melted in crucibles, set in rows in a furnace, each containing 176 pots. Both plain

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and coloured glass are made, the process taking from 8 to 12 days, according to the kind of glass that is being prepared.

PUNJAB.

Hallifax (**741,** 23) has given a general description of the glass making industry of the province. The materials used in Lahore and Jhelum are powdered sandstone and *sajji*, or carbonate of soda, mixed in equal proportions. Powdered quartz is used in Hoshiarpur. The articles manufactured are bottles, looking glasses, and bangles.

Reference may also be made to Baden Powell's 'Handbook' (**60—1**, Vol. II, 235).

GLAUBER SALT, *see* **SULPHATES—SODIUM.**

GNEISS, *see under* **BUILDING MATERIALS.**

GOLD.

Gold is very widely distributed throughout India, more so perhaps than any other useful mineral, with the exception of iron ore. There is, in fact, hardly a province in which the washing of alluvial gold from the sands of the rivers is, or has not been practised by the native inhabitants, though the quantity now won in this way is of very insignificant proportions, whatever it may have been in the past.

A strong distinction may be noted between the conditions under which gold occurs in the north of India, and those prevailing in the south. Everywhere in the region surrounding the Indo-Gangetic plain, including the valley of the Brahmaputra in Assam, the gold is derived, not directly from the rocks into which it was originally introduced, but from formations which are themselves of a detrital nature. That is to say, the gold which is now being washed out of these rocks was introduced with the transported material of which they are composed. Such gold may therefore be called alluvial or detrital in a double sense. Thus the immediate source of the gold may be found in rocks of very diverse geological ages, including the Tertiary sandstones and conglomerates of the Siwalik hills.

On the other hand, with a few exceptions where the river valleys are occupied by the Gondwana formations, the gold of southern India is obtained, either directly from quartz veins and schists belonging to a single formation of great age, or from recent alluvial deposits whose intimate connection with the auriferous reefs may

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in most cases be readily determined. This formation, consisting of chloritic, hornblendic, and quartz-hematite schists, phyllites, and quartzites with bands of conglomerate, traversed by a net-work of quartz veins and instrusive basic dykes, was originally supposed to belong to the great gneissic series of the Peninsula, but was recognised by Foote in 1886 (**596**—31) as a distinct system, to which he gave the name 'Dharwar.' These rocks are ancient highly metamorphosed sediments, once spread over an immense area, whose sole remaining vestiges form a number of parallel bands and outlying patches, representing the lowest portions of a series of compressed synclinal troughs, the upper portions of the folds having been entirely removed by long continued denudation.

As Foote pointed out in 1874 (**596**—11), the reef quartz is of two kinds, the one a blue or deep grey diaphanous variety, the other milk-white and more or less opaque. Maclaren has shown (**1134**—4, 124) that the blue quartz is associated with the metamorphosed igneous rocks,—the hornblendic schists,—and that its colour is due to the development of shear planes caused by intense strain, which has not affected the white variety. The latter is connected with the intrusion of the basic dykes, and belongs to a later period of thermal activity. Both varieties are at times auriferous.

The following writers deal with the occurrence of gold in India generally :—

1840. Burr (**238**—1). Discusses the prospects of profitable gold mining in India.

1880. Ball (**71**—40). A general summary of the information available.

1880. Eastwick (**527**). An attempt to show that the enormous stores of gold recorded as having been seized by former invaders of India came from the Wynaad mines. Identifies India with the land of Ophir.

1881. Hyde Clarke (**322**). A summary of the history and prospects of gold mining in India, with special reference to the Wynaad.

1881. Ball (**71**—44, 95). A general account of the mode of occurrence and distribution of gold in India.

1882. Lock (**1082**, 269—468). A summary of information relative to the occurrence of gold.

1901. Evans (**555**—9, 157). Discusses the prospects of the development of the gold mining industry.

1908. Maclaren (**1134**—10). A history of gold mining in India, with an account of the Dharwar system and the gold fields connected with it.

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1908. Maclaren (**1134**—11, 48—54, 227—270). A general treatise on gold. Discusses the origin of the gold in the Dharwar system.

The following deal more especially with the gold of southern India :—

1878. Maylor (**1194**—1). Notes on the occurrence of gold.

1882. Wood (**1959**). Remarks on the development of gold mining.

1883. Ball (**71**—58). Discussess the prospects of profitable gold mining in southern India.

1883. Leighton (**1052**). Gives a history of the gold mining 'boom' of 1879-1881.

1885. Anon. (**35**—37). An account of the revival in Indian gold mining.

1887. Marsh (**1176**). Notes on the occurrence of gold and other minerals in Mysore.

1887-1889. Foote (**596**—33; —34). Gives details of the geology of the bands of Dharwar rocks in the Indian Peninsula, with notes on the occurrence of alluvial gold in connection with them.

1891. Mervyn Smith (**1654**—3). Discusses developments in the gold mining industry.

1906. Maclaren (**1134**—4). A detailed account of the geology and petrology of the Gadag band of Dharwar rocks, with results of gold washing trials.

1906. Maclaren (**1134**—6). A comparison of the Dharwars of India with the auriferous rocks of Australia and S. Africa. These three regions are considered to form a single petrographical province, for which the name 'Erythræan' is proposed.

(see also below ;—MADRAS, MALABAR, and MYSORE, **Kolar**).

During the quinquennial period 1909 to 1913, India occupied the eighth position among the gold-producing countries of the world, with an average annual production of £2,242,305 or 2·37 per cent. of the total. In 1914 the production was 607,388 oz., or £2,338,355; and in 1915, 616,728 oz., or £2,369,846.

AFGHANISTAN.

Drummond (**504**—2, 89) and Masson (**1189**—1, Vol. I, 213) say that quantities of gold are brought down by the rivers of Lughman and Kunar, draining the southern slopes of the Hindu Kush, in Kafiristan. PESHAT (34° 43′ : 70° 57′) on the Kunar R. is specially

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mentioned as a locality where gold washing is carried on. Gold is also collected in the Kabul R. near CHARBAGH (34° 40′ : 70° 14′ 30″) and JELALABAD (34° 25′ : 70° 24′ 30″).

KANDAHAR (31° 37′ : 65° 43′). In 1873 Bellew (**103**—2, 30) gave a description of a gold mine situated 3 miles to the N. of Kandahar, and in 1881 the locality was visited by Griesbach (**708**—4, 55). The gold occurs in quartz veins traversing the zone of contact between Cretaceous (hippuritic) limestones and outbursts of trap, with traces of copper and nickel. Gold is said to have been found in paying quantities, but owing to mismanagement, the mines had fallen in, and were abandoned shortly before they were seen by Griesbach. The contact zone was traced to the S. W. for a distance of about 7 miles (**B.** 208).

ASSAM.

Under native rule Assam is said to have enjoyed a high reputation as a gold-producing country, but several reasons have combined to render the industry unprofitable, and within the last 60 years it has become practically extinct. An interesting account of it, under the old conditions, was compiled in 1838 by Moneeram (**1240**). He gives a list of the rivers known to carry gold (*see below*), and describes the method practised by the *sonwals* (gold washers). A suitable spot, generally at a sharp bend in the stream, is selected and tested. A portion of the stream is then diverted in order to sluice away the superincumbent sand and expose the auriferous gravel. This is washed through a bamboo strainer (*ban*) into a trough or cradle (*durani* or *durongi*), hewn from a log of wood, about 4 ft. long by 16 ins. wide and 4 ins. deep, in which the sand is washed off by a gentle stream of water, the heavy minerals being concentrated in a longitudinal groove at the head of the trough. At the end of the day's work the concentrates are again washed in the *durani* in order to separate as much as possible of the black sand, and the residue is rubbed with mercury in an earthenware bowl. Finally, the amalgam is placed on a Unio shell, heated over a charcoal fire, and the calcined shell is thrown into water, when the gold sinks to the bottom. When the colour is not satisfactory the gold is refined by re-heating with a mixture of burnt clay and salt. Robinson (**1503**—1, 35) and Butler (**249**—1, 130) have given similar accounts of the process (**B.** 218).

About the year 1853 Dalton and Hannay were deputed to report on the auriferous deposits of Assam (**760**—4; **408**), and their enquiries have been supplemented by a more precise investigation

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carried out on certain of the rivers by Maclaren (**1134**—3) in 1903-04. The results of these enquiries are briefly noted below.

The gold in the majority of the rivers is considered by Maclaren to be derived from the Tipam or Sub-Himalayan sandstones and conglomerates, a formation of upper Tertiary age. Originally, he thinks, the gold may have come from the crystalline rocks of the Miju ranges, lying between the head waters of the Lohit-Brahmaputra and the Irrawaddy.

Darrang.—Wade (**1861**, 128) in 1807 mentions the BARAPANI (?Borholi, 27° 0′ : 92° 50′) and the BURAGAON or BARGANG (26° 55′ : 93° 18′) as bringing down considerable quantities of gold. The BORHOLI is also mentioned by Hannay (**760**—2) as one of the most prolific rivers in Assam. No more precise information appears to be available.

Lakhimpur.—BURI DIHING. Maclaren found gold bearing gravels between MOKO (27° 23′ 30″ : 95° 51′ 30″) and the mouth of the KHERIM PANI (27° 26′ : 95° 56′), but the gold was extremely fine and flaky, and in no case did it exceed 1 grain to the ton of gravel.

DIBONG. Fairly coarse gold was obtained opposite NIZAMGHAT (28° 14′ : 95° 46′), but not worth more than 2 grs. to the ton (Maclaren, **1134**—3, 223).

DIGARU MUKH (27° 53′ : 96° 7′) both Dalton and Maclaren report only very small quantities of gold.

DIHANG. Dalton (**408**, 92) obtained good results on this river, the gravels yielding 16·2 grs. to the ton. Maclaren (**1134**—3, 224) found small quantities of gold everywhere below PASIGHAT (28° 4′ 95° 21′), and considers SIBIA MUKH (27° 54′ : 95° 30′) to be the most favourable locality, but no banks suitable for dredging were seen.

DIKRANG (27° 5′ : 93° 55′). This river, according to Wade (**1861**, 128), was formerly esteemed the best in Assam, as regards both the quality and quantity of its gold.

JANGLU or JOGLO PANI. Dalton (**407**—4) estimated the outturn of gold in this stream at 18 grs. to the ton, but Maclaren (**1134**—3, 217) reports that the quantity of auriferous gravel is very small, and that the yield was about 0·2 grs. to the ton. The gravels occur only near the mouth of a small tributary stream, the HONE JAN (27° 19′ : 95° 37′ 30″).

LOHIT-BRAHMAPUTRA. Two localities between Sadiya and Brahmakund were tested by Dalton and Hannay (**408**). At GURI MARA (27° 49′ : 95° 56′) the yield was from 12 to 13·3 grs. to the ton.

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At PARGHAT (27° 53′ : 96° 16′) gold was found only in small quantities, and the yield is not mentioned. Maclaren (**1134**—3, 223) considers the gravel beach at Guri Mara to be worthy of further prospecting, though he obtained only 2·3 grs. to the ton by dish trials. He obtained "colours" all the way between Digaru Mukh and Brahmakhund, but the beaches were very small.

NOA DIHING (27° 33′ : 96° 0′). Dalton and Hannay (**408**, 91) found the gold of this river to be extremely fine, and liable to be carried away in the washing. The yield is said to have been larger than in the Brahmaputra, but decreased on approaching the hills.

SISI (27° 32′ : 94° 45′). Dalton (**407**—4, 514) estimated the average yield from this river to be 15 grs. to the ton.

SUBANSIRI. This was formerly one of the most productive rivers in Assam. In 1853 Dalton (**407**—4, 514) estimated the average annual output at about 54 oz. Some excitement was caused in Calcutta in 1884 by a statement published in the *Englishman* (June 2nd) that assays of the sand had yielded 52 oz. of gold to the ton; but King (**987**—31) has pointed out that the assays were made on a sample of the concentrated sand. Maclaren (**1134**—3, 224) found that the area in which gold may be obtained is restricted to some 6 miles below the gorge by which the river issues from the hills. He considered that the most promising beaches were those situated below a large pool at the mouth of the DERPAI (27° 31′ : 24° 21′). The total quantity of gold obtainable from the sand, after removal of the coarser material, is estimated at 28 grs. per cubic yard. Actual washing trials, without amalgamation, yielded 20 grs. per cubic yard. The most advantageous method of exploiting the deposits is discussed at p. 229 *seq.* of the report.

TENGA PANI. Auriferous gravels were found by Maclaren (**1134**—3, 221) between LATAU (27° 45′ : 95° 59′) and CHONKAM (27° 48′ : 96° 6′), but generally containing far less than ½ gr. of gold to the ton.

Sibsagar.—Three rivers in this district are especially mentioned by Hannay (**760**—2, 628) as carrying gold. These are the DESOI or DESUE, DHANSIRI, and JANJI. He was informed that on the Desoi and Dhansiri 15 men, working for 12 days, could obtain rather less than 3 oz. of gold. On the Janji the same amount could be obtained in 20 days.

Maclaren (**1134**—3, 226) was informed that washing is only carried on in the Desoi for a distance of 12 miles below the GOAT JAN (26° 35′ : 94° 26′), a small branch of the main stream, and that the gold is very finely divided and not plentiful.

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BENGAL.

Midnapore.—In 1855 a sample of gold dust from the neighbourhood of MIDNAPORE (22° 25′ : 87° 24′), probably from the Kasai R., was examined by Piddington (**1405**—69). It contained particles of a yellowish-white, malleable and tough mineral, supposed to be a sulphuret of gold. The gold is probably derived from Dharwar rocks in the Manbhum district, about the head waters of the river.

BIHAR AND ORISSA.

The occurrences of gold in this province are confined to the southern portion, or Chota Nagpur division, which is traversed from east to west by a formation consisting mainly of argillites, phyllites, mica and talc schists, now correlated with the Dharwar, or auriferous series of southern India. The geology of this region has been described by Ball (**71**—46), and again, with especial reference to the occurrence of gold, by Maclaren (**1134**—1). As in S. India, the Dharwar rocks are traversed by quartz veins of two kinds, differing in physical characters and in the period of their deposition; but here, in contrast with the conditions prevalent in the typical area, the development of gold is associated with the later generation of veins, in which the quartz is white and opaque, and has not been subjected to orogenic strain. These veins are connected with considerable outbursts of basic igneous rock. According to a report by F. H. Smith, quoted by Griesbach (**708**—34, 10), the richest veins are mere leaders of quartz only a few inches thick.

Many old workings have been met with along the outcrops of the veins, together with large numbers of grooved stones which had been used for crushing and grinding the quartz (Holland, **859**—40, Maclaren, **1134**—1, 68); but none of the pits appears to have been carried to a greater depth than 15 ft., and they were probably made for prospecting purposes only.

The quartz veins are exceedingly numerous, and alluvial gold is consequently present in practically every stream, but in no great quantity. The implements used by the native gold-washers are a wooden tray of nearly rectangular shape, called *patta*, and an iron hook, *korne*, with which the gravel is scraped from among the boulders and from crevices in the rocks in the bed of the streams. Amalgamation with mercury is not practised, but the washers are so expert that only the most finely divided gold is lost. Neither the quantity of the gravels nor the conditions under which they occur are favourable for hydraulic sluicing or for dredging on a remunerative scale.

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In addition to those mentioned above, general accounts of the alluvial deposits have been given by Hewitt (**833**, 417) and by King and Pope (**988**). The latter work is compiled from all the sources of information available in 1891.

The following occurrences are specially mentioned by various writers :—

Bonai.—BONAI (21° 49′ : 85° 1′). Gold is obtained from the bed of the Brahmini R. at this place (**B.** 195).

DURJING (21° 56′ : 84° 57′). The conditions here, according to Maclaren (**1134**—1, 88), would be suitable for 'pond dredging,' but the average yield from the alluvial gravels was found to be not more than $\frac{1}{4}$ gr. per cubic yard.

Gangpur.—Gold is washed in the Ib. R. and some of its tributaries, particularly the Icha, at and below GIRINGKELA (22° 8′ : 83° 50′ 30″)—(**B.** 195).

Manbhum.—A series of trials extending over 66 days was undertaken by Ball (**71**—7) in 1867 in the southern part of the district. Gold was found in nearly all the streams, but the average yield obtained by two native washers was rather less than $\frac{1}{2}$ gr. a day. The SUBARNARIKHA and its tributaries, the KARKARI and BAMNI, also the TUTKO and KOWARI, tributaries of the KASAI (COSSYE), are said to be the most productive streams. PATKUM (23° 2′ : 86° 0′) on the Karkari is mentioned by Maclaren (**1134**—1, 83) as a favourable locality (**B.** 190).

Some crushing tests made in 1896 by Anderson (*see* Oldham, **1324**—52, 4) on a quartz reef at DHOBNI, near BOROBHUM (23° 2′ : 86° 25′ 30″), proved disappointing, the quartz containing practically no gold.

Mayurbhanj.—Bose (**173**—20, 170) mentions an auriferous tract, about 2 sq. miles in extent, surrounding the villages of KUDERSAI (22° 26′ 30″ : 86° 17′) and SAPGORA, at the head waters of the Borai R. Gold was found to a depth of 2 ft. in the alluvium. The richest deposits occurred in the neighbourhood of dioritic dykes with iron pyrites, traversed by thin veins of quartz. Deposits of similar extent were found on the Godia stream, near RUASI and GOHADONGRI (22° 24′ : 86° 20′). Here a layer of gravel, 3 ft. thick and covered by 12 to 15 ft. of alluvium, was found to be the richest portion of the deposit.

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Sambalpur.—Ouseley (**1349**—3) has described the process of gold washing, as practised in the Mahanadi at SAMBALPUR (21° 28′: 84° 2′), and Kittoe (**994**—5, 376) says that it is found in many of the streams flowing from the gneiss in the neighbourhood of the town. Ball (**71**—29, 190) found a party of gold washers at work on the Ib R. at TAHUD (21° 36′: 84° 2′), but gives no particulars of the yield. He thought that the gold in these rivers might be derived either from the gneiss or from conglomerates of Talcher (lower Gondwana) age; but since the discovery by Maclaren (**1134**—1, 72) of Dharwar rocks in the valley of the Ib, it is not necessary to seek further for the source of the gold (**B.** 200).

Singhbhum.—Except where otherwise stated, the localities noted below are taken from lists given by Haughton (**785**—1, 107) and Ball (**71**—46, 142). The lists merely serve to indicate the places most frequented by the gold washers (**B.** 192):—

ASANTORIA (22° 36′: 85° 33′ 30″). Gold is said to occur *in situ* in the neighbourhood.

DHIPA (22° 26′: 85° 16′). Small quantities of gold are obtained from the Koel R. here and at ANANDAPUR, a few miles higher up the river.

GURHA R. Oates (**1315**, 436) says that 15½ grs. of gold were obtained in two weeks' washing at a point 4 miles to the E. of RAJDOHA (22° 42′: 86° 21′). About 1 ton of gravel per day was washed.

KAMERARA (22° 15′: 86° 43′). The sand of the Subarnarikha R. here contains gold.

KAPARGADI PASS (22° 38′: 86° 23′). A nugget of gold is said to have been found close to the pass.

LANDU or NADUP (22° 44′: 86° 15′). The copper ores at this locality were found by Stoehr (**1711**—2, 353) to be slightly auriferous.

PAHARDIAH (22° 30′: 85° 16′). In 1901 a certain amount of development work was carried out here on a series of quartz veins or beds of quartzite, in which visible gold had been detected. The occurrence has been described by Hatch (**784**—2), who obtained an average yield of 4 dwt. of gold from 6 samples taken from several of the veins. According to Maclaren (**1134**—1, 78), the gold is associated with thin veins of white opaque quartz, penetrating blue pyritous quartz belonging to an older period of deposition.

PORAHAT (22° 36′: 85° 30′). Gold washing is practised in the Sanjai R. The locality is mentioned by Maclaren (**1134**—1, 83) as one of those most frequented by the gold washers of the district.

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SAUSAL (22° 38′ : 85° 30′). The mode of occurrence of gold at this place is described in detail by Maclaren (**1134**—1, 76) as typical of the whole area. The gold is confined to a few thin 'leaders' of quartz with argentiferous galena, extremely irregular in extension, penetrating chloritic schist. The best samples showed about 2 dwt. of gold to the ton; but not more than a ton of the quartz was available in sight.

SONAPET (22° 53′ : 85° 44′). The Sonapet valley has always enjoyed the reputation of containing more gold than other parts of the district. The discovery of rich specimens in 1888, followed by some prospecting, led two years later to much wild speculation in Calcutta; but during the year 1892 a complete collapse set in, and of 32 Companies, with a capital of nearly a million pounds, floated in the early days of the 'boom,' but two remained in existence at the end of the year. An examination of the deposits made by Noetling (**1311**—2) in 1889 tended to confirm the exaggerated reports of their value, though no definite trials seem to have been undertaken. Later investigation by Maclaren (**1134**—1, 82) has shown that the mass of the alluvial ground contains from 1 to 1½ gr. of gold per cubic yard; and that the yield from the 6 inches or so of bottom gravels is not more than 2 grs. per cubic yard. The conditions are favourable for the storage of water for hydraulic sluicing; but the low value of the gravels precludes any hope of a profitable return. The localities considered by Maclaren (*l.c.*) to be the most promising from the prospector's point of view are (*a*), the high range between MANHARPUR STATION (22° 22′ : 85° 16′) and ANKUA (22° 18′ : 85° 20′), where 4 samples from the Sukha stream showed an average of 2 grs. of gold per cubic yard; and (*b*), the country lying between SONAPET and SAUSAL.

Talcher.—Gold is reported by Blanford and Theobald (**150**, 88) to be washed occasionally in the TIKIRIA R. (21° 9′ : 85° 0′), and its tributary the OULI. The quantity collected is said to be very small (**B.** 189).

BOMBAY.

Belgaum.—BELVADI (15° 43′ : 74° 58′ 30″) and HONGAL (15° 49′ : 74° 55′). Aytoun (**51**—1, 8) says that he obtained gold by washing in the streams that flow into the Malparba R. near these places; but Foote (**596**—11, 141) was unable to confirm the statement (**B.** 207).

MURGOD (15° 53′ : 74° 59′ 30″). Foote was informed that small quantities of gold are obtained from the stream beds near the town (**B.** 207).

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Bijapur.—GULUDEGUD (16° 3′ : 75° 51′). A report that gold occurs here is considered by Foote (**596**—11, 142) to have no foundation in fact.

Dharwar.—DAMBAL (15° 18′ : 75° 50′). The existence of alluvial gold in the streams draining the northern and western flanks of the Kappatgod hills near Dambal was reported by Newbold (**1294**—15; —29, 209) in 1840. Large numbers of *Jalgars*, as the local gold washers are called, were then engaged in collecting gold from the streams between DHONI (15° 17′ 30″ : 75° 47′) and SURTUR (15° 14′ 30″ : 75° 40′ 30″), especially after heavy rains. The total annual outturn was estimated at about 200 oz.; but when Foote visited the field about 30 years later he found only three men at work.

Trial washings made by Aytoun (**51**—1, 2) in 1854, and subsequently by Le Souef and Schott (*see* Balfour, **69**—8, 2nd Edn., Vol. II, 349), did not give favourable results. In 1874 Foote described the geology of the tract (**596**—11), and the *Jalgars'* method of washing. A cradle about 3 ft. in length, made of light planks, was used for concentrating the sand, which was afterwards panned off in a wooden tray, and the residue treated with mercury. From 1½ cubic yards of gravel collected at what were considered to be the most likely spots the yield was a trifle over 6½ grs., or about 4 grs. per cubic yard (**B.** 204).

During his survey of the Dambal tract, Foote (*l.c.*, 135) discovered an auriferous reef to the N. of the village of ATTIKATTI (HUTTEE-KUTTEE, 15° 16′ 30″ : 75° 43′), with abundant indications of ancient gold workings. About 30 years later the reef was prospected by the Dharwar Gold Mines Co., and in 1907 mines were opened by the Dharwar Reefs Gold Mining Co., near the village of KABULAYAT-KATTI or KABLIGATTI (15° 18′ : 75° 42′), in the northern portion of this reef. In that year 4,916 crude ounces of gold were produced, and in 1908 the output was increased to 7,242 oz.; but it then began to decline, and the mines, together with others that were being developed in the neighbourhood, were closed in 1911. The operations at Kabligatti have been described by Ahlers (**16**—1) and Reuning (**1474**).

The Kabligatti series of reefs has been traced southwards for a distance of 8 miles into the Sangli State, and a parallel series occurs near HOSUR (15° 18′ : 75° 38′), about 3½ miles to the west. In both these areas there are numerous traces of old workings. These reefs were also being developed in 1906 by the Dharwar Gold Mines and other Companies, but none of them appears to have ever reached the producing stage, and the mines are now closed.

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The Dambal gold field is situated near the northern end of a band of Dharwar rocks, described by Foote (**596**—34, 49) as the Dambal-Chiknayakkanhalli, and by Maclaren (**1134**—4, 97) as the Gadag band. Reefs are very numerous, but of no great extent or thickness. The value was found to vary from nil to 3 oz. 15 dwt. to the ton. Two sets of reefs were distinguished, one consisting of diaphanous blue quartz, associated with the metamorphosed igneous rocks, and a younger series of ferruginous white quartz veins, which at Kabligatti are associated with carbonaceous argillites. At Hosur the rocks in the immediate vicinity of the quartz veins are talc and chlorite schists. The ancient workings, which in places attain a depth of 300 feet, are confined to the reefs of white quartz, but according to Ahlers, the blue quartz is sometimes also auriferous.

Kathiawar.—Jacob (**924**—2, 35) states that gold in small quantities is obtained from the sands of the Sourekha R., which rises in the Girnar hills (21° 32′ : 70° 35′). These are said to be composed of granite, probably of Cretaceous age, traversed by veins of quartz (**B.** 208).

BURMA.

Bassein.—Paton (**1374**, 379) says that gold dust and silver are washed from the sands of the watercourses in the neighbourhood of BASSEIN. The quantity obtained is apparently small.

Bhamo.—The gravels of the MOLE KYAUNG (24° 20′ : 97° 13′), and of the TAPING (24° 17′ : 97° 16′), so far as the latter river lies within British territory, were examined by Maclaren (**1134**—9, 114) in 1906, but were found to be commercially valueless. Griesbach (**708**—22, 129) mentions an occurrence of gold in decomposed gneiss at MYOTHAT, on the Taping R.

Chindwin (Lower).—Bion (**127**, 250) reports that gold washing is carried on spasmodically during the rains at ALON (22° 12′; 95° 8′) and KANI (22° 27′ : 94° 53′). A little gold is also won in the bed of a torrential stream descending from the Mu-Kyaukka watershed near THAZI (22° 14′ 30″ : 95° 18′). At Kani the gold is said to have been collected by placing the horns of wild cattle, with the hair on, in the bed of the river (**B.** 230). Bion, however, does not mention this practice.

Chindwin (Upper).—In 1832 the occurrence of alluvial gold in the Ningthee or Chindwin R. was noted by Grant (**692**—1) with a description of the method of gold washing, which is similar to that

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practised in Assam, except that mercury does not appear to have been used. In a second paper (**692**—2, 125) he says that all the streams entering the Chindwin from the eastern side above HILAO (HELAW, 24° 10′ 30″ : 94° 43′) carry gold (**B.** 227).

In 1836 the Hukawng valley was visited by Hannay (**1385**, 270; **760**—6, 12), who reported that gold is found in all the streams draining the valley, and that it occurs in greatest abundance in the Kapdup and Namkwan. He says that pieces the size of a large pea are occasionally found (**B.** 230).

During the course of an investigation of the auriferous gravels of Burma, the Upper Chindwin area was visited by Maclaren in 1906, but his report was regarded as confidential, and has not been published. Some details were given in a communication to the *Mining Journal* (**1134**—9) in 1907, but the following information is abstracted from an exhaustive report submitted by Bion in 1913 (**127**). The localities visited are situated partly on the main river, and partly on the Uyu, which flows in below HOMALIN (24° 52′ : 94° 57′). Gold was found both in the recent river gravels and in old terraces above the present flood level.

(1) In the main river.

HELAW (24° 10′ 30″ : 94° 43′). Recent gravel deposits occur at the heads of two islands (HELAW and GYOGON), and on a small beach at YWATHA, extending in all for a distance of about 1½ mile along the river. In each case the gold was found to be confined to the uppermost layer of gravel, seldom more than a foot in thickness, overlying sand with no gold. Its distribution in this superficial layer is also very inconstant. Of 16 trial pits put down, only three showed more than a grain of gold per cubic yard. The average yield was not more than half a grain.

Trials were made at several places above Helaw, both in the recent gravels and in the river terraces, but in every case the washings yielded only traces of gold.

(2) In the Uyu river.

KHAUNG-NGO (24° 48′ : 95° 14′). Gold is washed from sand banks in the bed of the river. The average yield was estimated at about 2 gr. per cubic yard.

KYOBIN (24° 50′ : 95° 20′). In the neighbourhood of this village gold is obtained from terraces of the older alluvium, composed of alternating, lenticular beds of sand and gravel, rising to an average height of 50 ft. above the present river level. The deposits are worked by a system of ground sluicing. Water is led in channels to the foot of the scarped faces of the terraces, and the material dug from them is washed in tail races, connected with the

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channels, for several days. The sand is then cleaned up and panned off in the usual way.

The results obtained from a large number of trial pits and trenches show that, although rich pockets are sometimes met with, the average yield is rather less than 2 grs. per cubic yard. In one instance 5·556 grs., and in another 4·474 grs. per cubic yard were obtained. All the terraces examined lie within a radius of a mile from Kyobin.

Similar terraces are reported to be worked at MEKKALEK (not shown on map), and in the neighbourhood, but these were not visited.

The district produced 45·6 oz. of gold in 1914, and 50·25 oz. in 1915.

Karenni.—O'Riley (**1340**—9, 53) states that he obtained small quantities of gold in the MYET-NAN-KYAUNG, to the E. of Toungoo. He was informed that the Burmese had obtained a considerable amount of gold at this locality.

Katha (Wuntho).—KYAUKPAZAT (24° 6′ : 95° 54′). A specimen of auriferous pyrites from the head waters of the MEZA R., to the N. of Wuntho, was analysed by Romanis in 1886 (**1511**—10; —12), and found to contain 87·66 per cent. of gold. Concentrates from the same locality gave 74·83 per cent. of gold with small quantities of platinum and iridosmine. In 1894 the tract was examined by Noetling (**1311**—18, 117), when the source of the gold was found in a network of pyritous quartz veins traversing a series of bedded andesitic tuffs, possibly of Devonian age.

A mine was soon afterwards opened at Kyaukpazat, where Mr. C. M. P. Wright had discovered traces of old Burmese workings. The vein, as described by Stonier (**1715**—1), was 240 ft. in length with an average thickness of 3 ft. 6 ins. In 1900 it had been proved to a depth of 420 ft. The average yield of gold was about 14 dwt., of which 9 dwt. was extracted by milling. The mining operations have been described by Bromly (**200**) and Maclaren (**1134**—9), and the process adopted in cyaniding the ores by Wright (**1972**—1).

The output of gold from the mine increased from 1,120 oz. in 1898 to 1,984 oz. in 1902, but in the following year the pay chute was lost, and efforts to discover other profitable veins in the neighbourhood having failed, the enterprise was abandoned.

An auriferous vein of similar character, but only 9 ins. in thickness was discovered by Stonier (**1715**—1, 63) at a spot about 14

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miles to the N. of BANMAUK (24° 24′: 95° 54′). Where tested it contained 9 dwt. of gold to the ton, with 2 per cent. of copper.

Kyaukse.—Middlemiss (**1219**—22, 151) was informed that gold occurs *in situ* in quartz rock or gneiss on a hill about 3,000 feet high, about 10 miles to the N.E. of MYOGYI (21° 27′: 96° 24′) in the Baw State. This is perhaps the site of a 'gold mine' mentioned by Strover (**1721**) as occurring near the Myitnge R. to the S.E. of Mandalay.

Mergui.—Both Helfer (**808**—5, 33; —7, 231) and Bose (**173**—18, 163) mention gold washing on a small scale in the Tenasserim R. at the old town of TENASSERIM (12° 5′: 99° 3′), and Helfer also speaks of its occurrence in the tributaries of the LAMAING R. The attention that has been bestowed of late years on the alluvial deposits of tin ore in the district renders it improbable that gold should have escaped notice, if it occurs in payable quantities.

Page has reported (*see* Holland, **859**—71, 56) the existence of gold washings on HORSBOROUGH I. (10° 12′: 97° 55′), and of pyritous veins carrying 10 dwt. of gold to the ton on RUSSEL I. (?), in the Mergui Archipelago.

Myitkyina.—In 1901 a concession was granted to Messrs. Moore and Terndrup for dredging in the Irrawaddy for a distance of 120 miles below the confluence of the Malikha and the 'N Maikha (25° 44′: 97° 33′). The concession is now held by the Burma Gold Dredging Co., and covers about 60 miles along the course of the main river, 25 miles on the eastern branch, the 'N Maikha, and 5 miles along the Malikha. The number of dredges has been increased from one to five. Gold is disseminated fairly uniformly in the gravel. The average value is about 3 grs. per cubic yard.

The annual output during the first five years of working increased from 370 oz. to 7,950 oz., and in 1909 reached 9,041 oz. It then fell off to an average of 5,270 oz. for the four years 1910 to 1913. The output in 1914 was 3,635 oz., and in 1915, 3,107 oz.

Pakokku.—Scott (**1601**, Vol. II, Pt. 2, 722) records that gold was washed up to the time of the annexation of Upper Burma in the Bahonchaung near CHAUNGZONGYI (21° 49′: 94° 48′). Small quantities of gold are still returned as being procured in the district. The combined output from Katha and Pakokku was 20·31 oz. in 1913, and 12·59 oz. in 1914.

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Prome.—SHWEGYAING (18° 3′ : 95° 30′). Gold washing on a small scale was witnessed by Theobald (**1763**—16, 343) at this place. The gold was found in a bank of coarse gravel, left dry by the river after the rains (**B.** 228).

Shan States (N.).—LOI SAR (22° 41′ : 96° 31′). A small area in the southern part of the Möng Lông State, in which it was reported that gold washing was practised by the Shans with good results, was examined by Coggin Brown (**211**—3) in 1911-12. The locality is difficult of access, and as the streams flow in deep, narrow ravines, the gravels are of limited extent. In the largest of the streams, the HWE-GNA-SANG, draining the eastern flanks of Loi Sar, the deposits cover an area of 9½ acres only. Trial pits gave an average yield of 3·185 grs. of gold per cubic yard. The highest yield, 9·687 grs. per cubic yard, was obtained from the bottom layer of a patch of gravel, about 1½ acre in extent, at KUNGWO, 2 miles to the S.E. of Loi Sar. The gold is derived from a series of quartzites and chloritic slates of pre-Cambrian age, traversed by numerous quartz veins. Although the gold is coarse grained, and is sometimes found adhering to quartz, none of the veins, when tested, showed any trace of gold.

NAMMA R. (22° 55′ : 98° 29′). In 1905-06 an attempt was made to exploit the auriferous gravels on the Namma R., a small tributary of the Salween, by dredging. Preliminary exploration had shown the existence of some 40 million cubic yards of gravel, with an average value of 5·43 grs. of gold per cubic yard. It was soon found, however, that the clay in which the pebbles and boulders are embedded had been hardened in places by infiltrations of carbonate of lime, which interfered seriously with the working of the dredge, and the venture ended in failure (**862**, 96).

Shan States (S.).—LOI TWANG (21° 56′ : 97° 43′). The existence of coarse gold in the streams on the northern side of Loi Twang, a hill situated at the junction of the Möng Tung, Kehsi Mansam, and Möng Küng sub-States, was brought to the notice of Government by the Sawbwa of Hsipaw in 1905. In the following year trial pits were put down and washings made by La Touche (**1034**—33) in all the streams draining the hill; but the results were disappointing, the quantity of gravel from which an average yield of more than a grain per cubic yard might be expected being very small. The gold is derived from sandstones, probably of Cambrian age.

The Shan gold washers use a circular wooden tray, hollowed to the form of a shallow cone, and painted with black lacquer on the

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inside, in order to show up the spangles of gold. Amalgamation with mercury is not practised.

MAGWE (20° 37′ 30″ : 96° 36′). Middlemiss (**1219**—22, 151) was informed that gold occurs about 4½ to 5 miles to the W.N.W. of Magwe, in the Thamakan State. It is said to be found in a quartz vein, and to be washed for in the streams to the N. and N. W. of the same place.

TAUNGLEBYIN (20° 40′ : 96° 29′). Jones (**952**—4, 194) was informed that gold is obtained from a stream near the village, but was unable to visit the place.

Shwebo.—THINGADAW (22° 57′ : 96° 0′). Oldham (**1326**—17, 336) and Anderson (**29**—2, 201) mention gold washings in the Kibiung and Ponnah streams, in the neighbourhood of the Thingadaw coal mines (**B.** 231).

Ten and a half ounces of gold are returned as having been collected in this district in 1914, and 7·31 oz. in 1915.

Tavoy.—KALEIN AUNG (14° 36′ : 98° 12′). Small quantities of gold are obtained, according to O'Riley (**1340**—3, 737; —6, 21) from the Dzin Ba Kyaung and the Im Ba Kyaung, near the head of the Tavoy river; and from the streams flowing into the bay of HENZAI (HEINZÉ, 14° 45′ : 98° 0′.)

Toungoo.—SHWEGYIN (17° 56′ : 96° 55′). A small sample of auriferous sand procured near the junction of the Mu-ta-ma and Shwegyin rivers, about 10 miles to the S.W. of Shewgyin, was reported on by Oldham in 1853 (**1326**—4) and 1856 (**1326**—11). One-fifth of a cubic foot of sand yielded 0·95 gr. of gold, or at the rate of over 100 grs. per cubic yard; but subsequent exploration showed that the average value of the deposits was too low to repay the cost of working (**B.** 228).

CENTRAL PROVINCES.

The most recent information regarding the occurrence of gold in the Central Provinces is given by Nunn (**1313**) in a monograph on local gold and silver ware, published in 1904. With one exception, the gold is obtained by washing the sands of the rivers which drain areas occupied by Dharwar rocks. In quantity it appears to be no more than sufficient to afford occasional employment to a few individuals.

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Balaghat.—Lanji (21° 30′ : 80° 36′). Gold is washed from the sands of the Son and Deo rivers in Lanji pargana, according to Jenkins (**938**—1, 213), Wilkinson (**1933**, 292) and Hislop and Hunter (**843**, 380).

Mau (22° 13′ 30″ : 80° 12′). In the Nahr R.

Panchera (21° 55′ : 80° 16′). In the Sonabera R. (**B.** 202).

Bastar.—Kolar (19° 54′ 30″ : 81° 12′). Partabpur (19° 59′ 30″ : 80° 48′). In the Kolar R., according to Bose (*see* Griesbach, **708**—31, 38). The Central Provinces Gazetteer also mentions Bharamgarh (19° 25′ : 80° 39′ 30″), at the junction of the Kuthari and Indravati rivers (**B.** 202).

Bhandara.—Ambagarh (21° 26′ 30″ : 79° 43′ 30″). In the Maru stream, according to Wilkinson (**1933**, 292).

Tirora (21° 24′ 30″ : 79° 59′). In a small tributary (?Baghnadi) of the Wainganga (**B.** 202).

Nunn (*l.c.*, 7) quotes an account of the method of gold washing, which is similar to that practised in Jashpur and Singhbhum.

Bilaspur.—Sonakhan (21° 24′ : 82° 38′ 30″). In the Jonk R., according to Wilkinson. A former gold mine, beneath the hill at Sonakhan, is mentioned by Voysey (**1853**—7, 857)—(**B.** 201).

Jashpur.—Pharsabahal (22° 30′ : 83° 55′). A report submitted by Robinson in 1849, on a gold tract lying in the valley of the Ib R., in this neighbourhood, was published by Haughton (**785**—1, 107) in 1854. Great activity had been shown in working the deposits, which are described as being riddled with shafts from 21 to 60 ft. in depth. A full account of the operations of the *Jhoras*, or gold washers, was given by Dalton (**410**—1, 13) sixteen years later. A cradle, *dhuin*, is used for concentrating the sands, and a tray of smaller size than that used in Singhbhum, but twice as deep, for panning off the concentrates. A modified form of ground sluicing is also practised during the rainy season (**B.** 196).

No estimate of the value of the gravels has been published, but Robinson considered that they might be worked with profit. The gold is probably derived from bands of Dharwar rocks, discovered in this and the adjoining tracts by Maclaren (**1134**—1, 72).

Jubbulpore.—Sleemanabad (23° 38′ 30″ : 80° 19′). The metalliferous lodes in this neighbourhood, already mentioned under the heading **Copper**, have been found to contain a certain amount of gold, varying from *nil* up to 15 dwt. to the ton (**861**, 236).

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Mandla.—Gold is said to have been washed in the BANJAR R. before the famine of 1896—97, but the practice has since been abandoned as unprofitable (Nunn, *l.c.*, 6).

Raipur.—RAJOO or RAJIM (20° 58′ : 81° 56′). According to Wilkinson (**1933**, 292), gold is washed here from the bed of the Mahanadi R. (**B.** 201).

Seoni.—PACHDHAR (21° 44′ : 79° 31′). In the Pachdhar and Bawenthuri rivers. The takings are said to have averaged 3 or 4 annas a day (*see* Hayden, **793**—31, 20).

Udaipur.—RABKHOB or DHARAMJAIGARH (22° 28′ 30″ : 83° 17′). The deposits of the Mand R. here, as described by Haughton (**785**—1, 110) and Dalton (**410**—1, 22), are similar to those in Jashpur, and were worked in the same way. The yield of each *dhuin* or cradle is said to have been about 3 grs. a day.

Gold is also washed on the following tributaries of the Mand R. On the Bharari at BAKARUMA (22° 31′ 30″ : 83° 29′). On the Korija at KAMHAR (22° 35′ : 83° 18′ 30″). On the Maini at JAMARGI (22° 34′ : 83° 48′). And on the Sangul at SALKAO (22° 43′ : 83° 22′ 30″) and other villages in the neighbourhood (**B.** 198).

HYDERABAD.

Raichur.—The gold fields of this district are situated on the Maski band of Dharwar rocks, described by Foote (**596**—34, 34) in 1889. Large numbers of ancient workings were noticed at three localities :—

HUTTI (16° 12′ : 76° 43′). Now worked by the Hutti (Nizam's) Gold Mines, Ltd., an offshoot of the Hyderabad (Deccan) Co. The old workings here are the deepest known in India, one of the shafts at least reaching a depth of 620 feet.

Crushing began in 1903 with 10 head of stamps, since increased to 30. The total output for 11 years, 1903 to 1913, has been 150,740 oz., or a yearly average of 13,700 oz. The output in 1914 was 21,200 oz., and in 1915, 17,870 oz.

TOPULDODI (16° 10′ : 76° 51′). A mine was opened here by the Topuldodi (Nizam's) Gold Mines, Ltd., in 1908, when 2,132 oz. of gold were produced. Further development, however, showed that the ore is of very low grade, and the mine was soon closed.

WONDALLI (16° 14′ : 76° 48′). A subsidiary company was formed to open up the old workings here about the year 1891, but ceased operations in 1900. The most productive year was 1899, when

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18,970 tons of ore were crushed for a yield of 7,822 oz. (Maclaren, **1134**—11, 258).

Warangal.—Walker (**1868**—5, 184) mentions a tradition that a gold mine was formerly worked by the Paluncha Raja at GUDALUR near MUNGAPET (18° 15′ : 80° 35′), and that gold was washed in several of the streams flowing into the Godavari. Ball (*see* King, **987**—23, 199) thought that the gold procured from the bed of the Godavari at Mungapet, and at the mouth of the Kinarsani R. near BHADRACHALAM (17° 40′ : 80° 57′), is brought in by streams on the Hyderabad side of the river, and that it is doubly derivative from Kamthi (Gondwana) rocks (**B.** 187,203).

KASHMIR.

Baltistan.—BASHA R. (35° 41′ : 75° 30′). Vigne (**1846**—4, Vol. II, 287) says that gold dust is procured from the sands of this river, which is said to be the most productive in Little Tibet.

KAPALU (35° 10′ : 76° 24′). Gold washing at this locality is mentioned by Thomson (**1777**—3, 212).

Dras.—KHARBU (34° 33′ : 76° 3′ 30″). Old diggings in auriferous sands are mentioned by Bellew (**103**—3, 103). The deposits were examined in 1907 by Huntington (**897**—7, 52) with disappointing results.

Ladakh.—The occurrence of gold in the Indus and Shyok rivers is mentioned by Cunningham (**399**—5, 232), but no particulars of the yield are given.

ACHINATHANG (34° 31′ : 76° 42′ 30″). A number of pits made by Balti gold washers were noted by Drew (**502**—3, 267) in an alluvial terrace about 120 ft. above the Indus R. at this locality.

KIO or SKIO (34° 0′ : 77° 19′). Great numbers of pits, many of them of recent excavation, were seen here by Lydekker (**1109**—22, 49; —38, 333) in 1880. The gold is believed to have been derived from quartz veins in the neighbouring Kuling (Carboniferous) series (**B.** 213).

Rupshu.—PARA R. Small quantities of gold are said to have been obtained by Tibetans from sub-recent gravels at CHAGYA SAMDO (32° 32′ : 78° 42′), on the border between Rupshu and To-tzo. A small amount of material was panned by Hayden (**793**—9, 102), but no gold was found.

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The production of gold in Kashmir is subject to great fluctuations. In 1903 the output in Ladakh was 106 oz., but in the three following years it was returned as 24 oz., 10 oz., and 4·8 oz., respectively. Since the year 1905 the only output recorded has been 236 oz. in 1910.

MADRAS.

Anantapur.—A belt of Dharwar schists, including several large quartz reefs, was discovered in this district by Wetherell (**1915**—5), in 1902. Old gold workings were found near the village of RAMGIRI (14° 18′ 30″ : 77° 33′), and two Companies, the North Anantapur and Jibutil Gold Mines, Ltd., are now at work on the development of the property. The production of gold has risen from 2,532 oz. in 1910 to 23,870 oz. in 1915 (**862**, 92).

Bellary.—JAJKUL GUDDA (14° 51′ : 76° 6′ 30″). Gold was obtained by Foote (**596**—39, 196) from some of the streams draining the Jajkul Gudda, a hill lying about 6 miles to the E.N.E. of Harappanhalli. The streams in order of richness were the Konganahosur on the east; a small stream W. by N. of Chiggateru; and a stream near Changalu on the western side of the hill. Maclaren (**1134**—4, 119) says that exhaustive trials in the Konganahosur stream gave very poor results.

Coimbatore.—Some outlying bands of supposed Dharwar schists, associated with charnockite and basic intrusive rocks, on which old gold workings had been discovered by Mr. R. Morris, were reported on by Hayden (**793**—7) in 1901. Four sets of old workings were examined, situated at the following localities :—

BENSIBETTA (11° 42′ 30″ : 77° 21′). No free gold was observed in the reefs, but it occurs in the soil near the outcrop in considerable quantities. Samples taken from two old shafts sunk on small leaders of quartz gave an average yield of 7 dwt. per ton, and traces of gold, respectively.

HADABANATTA (11° 56′ 30″ : 77° 21′ 30″). Old workings are very numerous, but not more than 20 ft. in depth. The reef varies from 1 ft. 9 ins. to 8 ft. in thickness, and contains copper as well as gold. Of 12 samples taken only 2 yielded more than traces of gold.

KAVUDAHALLI (12° 4′ : 77° 30′). Old workings can be traced for about 3 miles. Prospecting operations have shown that the ore bodies are mere stringers of quartz, of no practical importance.

PORSEDYKE MINE, 1½ mile to the N.E. of PORSEGAUNDANPALAYAM (11° 53′ 30″ : 77° 21′). Three shafts had recently been sunk near

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some old workings on a large reef, but no traces of the reef had been found below ground.

Madura.—PALAKANATH (10° 27′ 30″ : 77° 52′). Small quantities of gold are obtained, according to Muzzy (**1278**, 101) and Nelson (**1286**, 30), from the detritus brought down from the Palni hills. It is also said to be found in the VEIGEI R. (10° 0′ : 78° 0′), draining the same hills further to the south (**B.** 179).

Malabar.—The occurrence of alluvial gold in the rivers and streams of the southern portion of the Malabar district has received attention at intervals since the year 1793, when information on the subject was supplied by the local officials to the Governor of Bombay (*see* Sheffield and Nicolson, **1617**). Reference is made to it by the following writers :—

1829. Young (**1983**, 48). Fine specimens of gold are said to be found in the rivers west of the Nilgiris.

1831. Sheffield (**1617**, 5). Gives a list of the streams which afford the largest supply of gold, and the results of an enquiry carried out by Lieutenant Nicolson. The quantity obtained by one man per day was from 2 to 6 grs. Two grains was considered a fair average. A Committee appointed to consider the question of working the deposits on a large scale came to the conclusion that they would not prove remunerative.

1835. Baber (**54**—2). Refers to the prevalence of gold in the rivers and streams draining the western slopes of the Nilgiri hills, and estimates the area over which the soil is impregnated with gold at 2,000 sq. miles. The washing was performed by slaves.

1847. Anon (**35**—35). A summary of Sheffield's and Nicolson's observations.

1857. Balfour (**69**—8, 2nd Edn., Vol. II, 348). Gives a list of the rivers and streams in which gold is found.

1896. Lake (**1025**—1, 238). States that gold washing is practised in many of the rivers, principally at NILAMBAR (11° 17′ : 76° 17′) and MANARKAD (11° 15′ 30″ : 75° 59′).

(Wynaad).—During the enquiry carried out in 1831, Nicolson had discovered the remains of numerous old gold workings, made by a mining people known as *Karumbars*, along the outcrop of quartz reefs in the S.E. Wynaad. About the year 1875, the Alpha Gold Co. was formed for the purpose of prospecting these reefs, and in that year a report on the alluvial occurrences of gold and on the

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distribution of the reefs was furnished by King (**987**—13). Many of them were found to be auriferous, and an average yield of 7 dwt. of gold to the ton was obtained from 15 trial crushings. In a second report, dated three years later (**987**—16), King gives full details of the prospecting operations which had been carried out in the interval by the Alpha and two other subsidiary Companies in the neighbourhood of DEVALA (11° 28′: 76° 26′) and PANDALUR (11° 29′: 76° 24′), where the most numerous and productive reefs are situated. From a total of 1,192 tons of quartz crushed, 271 oz., 9 dwt. 13 gr., of gold had been obtained, or an average of 4·5 dwt. to the ton.

Notwithstanding these poor average results, the occasional discovery of surprisingly rich leaders of quartz led to the flotation of no less than 33 companies between the years 1879 and 1881, with an aggregate capital of £4,050,000; but the quantity of gold produced was so small, amounting to no more than 630 oz. by the year 1883, according to Leighton (**1052**), that operations were gradually suspended, and the Alpha mine was finally closed in 1893.

During the course of the 'boom' the following reports and accounts of the gold field were published:—

1878. Pegler (**1379**). A report on the geology and auriferous reefs of the gold tract.

1880. Brough Smyth (**1671**). Gives a full account of the topography, geology, and mode of occurrence of the gold. The old workings and the methods of the native miners are described. The results of trial washings given in the report are more favourable than those obtained by King. Excluding some of exceptional richness, 88 samples yielded on the average 1 oz. 8 dwt. 22 grs. of gold to the ton; but the best average result obtained by the Alpha Co. is said to have been 10 dwt. 12 grs. to the ton from 322 tons of quartz crushed.

1880. Ryan (**1536**). Considers that the existence of gold in workable quantities, over an area of about 525 square miles, has been proved. Discusses the economic conditions of the field.

1880. Anon (**35**—36). A general account, compiled from Brough Smyth's and Pegler's reports.

1881. King (**987**—24). A brief description of the quartz reefs and their probable value.

1881. Jennings (**942**). Account of a visit to the gold field.

1881. Harvey (**781**). A general description of the reefs and of the native methods of working.

1881. Rowe (**1525**). A general account of the mode of occurrence of the reefs.

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1883. Darlington (*see* Hayden and Hatch, **794**, 6). Report on properties held by the Consolidated Gold Co. Considers the ore so deficient in quantity, and the quality so poor, that remunerative mining is impossible.

1896. Charleton (**304**). Describes the situation and geological features of the gold field. The average yield is said to have been seldom more than 1½ to 5 dwt. of gold to the ton.

During the years 1899 to 1900, a fresh investigation was undertaken by Hayden and Hatch (**793**—5; **794**), dealing principally with the reefs near Devala and Pandalur formerly worked by the Alpha and Phœnix Cos. respectively. Many of the reefs sampled were found to consist of a series of lenticular masses of quartz, or small isolated bodies of ore, in which the bulk of the gold was associated with sparsely disseminated strings and patches of iron pyrites. The average assay value of 174 samples from the Alpha mine was 1·6 dwt., and of 93 samples from the Phœnix mine 2 dwt. to the ton. No bands of ore were met with that would justify the continuance of prospecting operations.

MYSORE.

The fact that the table land of Mysore is traversed from north to south by the two principal bands of Dharwar schists, and that outlying bands and patches of the same rocks frequently occur within the limits of the State, accounts for a wide distribution of gold and of ancient gold workings in this part of southern India. With the exception of Bangalore, the existence of gold to a greater or less extent has been proved in every district, and from one of them, Kolar, comes 92·5 per cent. of the gold now produced in India.

The particulars of the occurrence of gold at the localities mentioned below are extracted, except where otherwise stated, from the descriptions of the Dharwar series published by Foote between the years 1882 and 1889 (**596**—22; —34).

Chitaldroog.—Halekalgudda (14° 27′ 30″; 76° 12′). Some fine quartz reefs were seen on the hills to the S.W. of the village. A good show of gold was obtained near the north end of the hills (**596**—34, 53).

Honnamaradi (14° 28′ 30″: 76° 25′ 30″). Highly promising quantities of gold were obtained from two streams on the E. and W. sides respectively of a small hill to the N. of the village. Medium sized quartz reefs were seen close by (**596**—34, 51).

Kotemaradi (14° 18′: 76° 28′). A small stream draining the western and northern slopes of the hill carries a notable quantity

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of coarse gold (**596**—34, 52). The tract was examined by Sambasiva Iyer (**1548**—2) in 1901, when several quartz reefs and old workings were discovered.

MALLA BENNUR (14° 21′ : 75° 48′). A very good show of gold was obtained from a small stream flowing into a tank near the village, from a ridge partly consisting of chloritic schists with small veins of blue quartz (**596**—34, 45).

NELABAIGUDDA (13° 50′ : 76° 39′). Several old workings were found by Sambasiva Iyer (**1548**—5, 110), some of them reaching 150 ft. in depth. Gold was obtained both from the surface soil and from quartz reefs.

Hassan.—GOLLARAHALLI (13° 10′ : 76° 20′ 30″): A small outlier. There are old workings of great superficial extent, but mostly very shallow. The eastern side appears to deserve deeper prospecting (**596**—34, 18).

JALGARANHALLI (13° 12′ : 76° 24′ 30″). No reef was seen in the old workings, but a good show of gold was obtained from scrapings (**596**—34, 18).

KARADIHALLI (13° 29′ : 76° 19′ 30″). An outlier of very small extent. Gold was obtained from the northern end by washing, and two or three reefs were seen (**596**—34, 17).

MALLANHALLI (13° 10′ : 76° 27′). A moderate show of gold was obtained from scrapings in a large pit, unconnected with any visible reef. A large reef of promising appearance was seen a little to the N. of the pit (**596**—34, 18).

NUGGIHALLI (13° 1′ : 76° 32′ 30″). Some old workings occur on Tagadurbetta, to the N. of the town. There are a few reefs of no great length or thickness. A very rich show of gold was obtained from scrapings in an old pit of large size at KEMPINKOT, near the southern end of the outlier (**596**—34, 19).

TELLAVARI (13° 20′ : 76° 20′). No good-looking reefs were noticed, but a fair show of gold was obtained from one of the small old workings (**596**—34, 18).

Kadur.—AJJAMPUR (13° 43′ 30″ : 76° 4′). Prospecting operations in connection with old workings on Honnegudda hill have been described by Sambasiva Iyer (**1548**—3). The hill is composed of schistose conglomerates, with veins and reefs of bluish white quartz rich in pyritous minerals, and yielding some gold on assay. The old workings are of large dimensions.

CHIKMAGALUR (13° 19′ : 75° 50′). Many of the samples collected by Balaji Rao (**68**-6) from bands of quartzite between KALASPUR

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(13° 17′: 76° 0′) and KARTIKERE (13° 17′: 75° 51′) showed traces of gold.

NANDI (13° 38′ 30″: 75° 55′). Old workings were found by Primrose (**1431**—5) about 1½ mile to the S.-W. of the village, and slight traces of gold in the surface soil. Slater (**1649**—6, 19) states that numerous old workings occur for a distance of about 16 miles to the south.

TARIKERE (13° 42′ 30″: 75° 52′ 30″). A little gold was found by Primrose (**1431**—4) in the surface soil, but no auriferous reefs were met with.

Kolar.—The narrow belt of Dharwar schists on which the Kolar gold field is situated has been traced for a distance of about 50 miles from north to south, but the productive quartz veins are confined to a portion of the band, some 4 miles in length, in the neighbourhood of MARIKUPPAM (12° 55′: 78° 19′ 30″). The earliest account of the occurrence of gold in this tract is due to Warren (**1891**—1), who was engaged in the survey of the eastern frontier of Mysore in 1802. Gold was found in the surface soil over an area of about 130 square miles. Especially rich deposits are said to occur in the valleys of the Poniar and Palar rivers, the yield in some cases amounting to 12·5 grains to the ton of alluvial soil. Mining on a small scale was in progress at or near 'MARCOOPUM' (MARIKUPPAM), where there were pits about 30 feet deep, with horizontal galleries at the bottom. These, as Newbold observed in 1845 (**1294**—44, 651), were not excavated in the solid rock, but in decomposed schist filled with fragments of quartz derived from the veins. The quartz extracted was pulverised by women, and the gold recovered by washing and amalgamation. In still earlier times, however, as recent development work has shown, the shafts were carried down into the solid quartz, to a depth in some cases of as much as 300 feet (**B.** 185).

The modern history of the field dates from the year 1871, when Lavelle obtained a concession covering 20 square miles in the Kolar district, and began sinking a shaft on the block now owned by the Ooregum Gold Mining Co. (*see* Evans, **555**—9, 162). Little progress was made until 1880, when large amounts of capital were subscribed for the purpose of opening up the reefs; but at first the conditions governing the distribution of payable ore within the veins was not understood, and much of the working capital was wasted in mining in barren ground and among the old workings. Finally, the Mysore Co. succeeded in 1885 in bottoming one of the old shafts at a depth of 229 feet, and discovered a rich

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'chute' of ore. Since then the history of the field has been one of practically uninterrupted success.

The following papers deal with the geology and industrial development of the field :—

1880. Anderson (**26**—1 ; —2). Accounts of a visit to the field.

1881. Mervyn Smith (**1654**—1). A general description of the ancient gold workings, and of early attempts to develop the industry on modern lines.

1882. Foote (**596**—22, 199). Notes on the geology. Defines the limits of the schist belt, and recognises its synclinal structure.

1886. Mervyn Smith (**1654**—2). A general report on the field, and an account of the ancient gold workings.

1886. Anon. (**35**—38). A general description of the geology of the district.

1888. Anon. (**35**—39). Notes on the development of the gold mining industry.

1889. Foote (**596**—34, 37). Supplementary notes on the geology of the field.

1889. Bosworth-Smith (**175**—1). A full report on the topography, geology and mineralogy of the field. Two sets of quartz veins are distinguished, the one composed of blue auriferous quartz in discontinuous, lenticular masses striking parallel with the foliation of the schists; the other of white quartz running in a transverse direction.

1890. Leveillé (**1067**—2). A brief account of the mines.

1893. Mervyn Smith (**1654**—4). A description of the old workings, and of the geology, with special reference to the Champion or principal lode.

1894. Elliott (**539**, 191). An account of the development of the field.

1896. Charleton (**304**, 355). Describes the geology of the field, and gives details of the working and output of the mines.

1898. Pitblado (**1407**). Gives an account of the process of cyaniding, as practised at the Mysore Co.'s mines.

1901. Evans (**555**—9, 159). Describes the geology of the field. Considers that the auriferous reefs are to be regarded as interstratified deposits rather than as fissure veins. Suggests that the multiplication of the reefs in the northern portion of the field is due to repeated folding and faulting, and that the structure is not that of a simple synclinal.

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1901. Hatch (**784**—1). A full report on the geology and mineralogy, and on the methods of mining and of gold recovery practised on the field. The distribution of the gold in payable 'chutes' within the Champion lode is described in detail.

1904. Mervyn Smith (**1654**—7). Describes the various members of the belt of schistose rocks in which the auriferous reefs occur, and gives a summary of previous observations.

1905. } Lethbridge { (**1065**—1, 3) } General accounts of the
1907. } { (**1065**—2, 41) } development of the gold mining industry in Mysore, with remarks upon the possibility of its extension.

The production of gold in this field has hitherto been entirely derived from the Champion lode, which has a length of about 4 miles, with an average width of about 4 feet. The total output, from the year 1883 to the end of 1913, amounted to £42,444,652. The maximum for one year was reached in 1905, when the value of the gold produced was £2,373,457. Since then, though there has been an increase in the tonnage of ore crushed annually, the yield has declined, the average value for the five years 1909 to 1913 having been £2,127,348. In 1914, 562,355 oz., worth £2,159,604 were produced; and in 1915, 571,199 oz., worth £2,185,409.

Mysore.—ARAKERE (12° 25′ : 76° 52′ 30″). Attwood (**50**, 646) mentions the occurrence of several promising quartz veins at the S. E. end of a band of Dharwar schists lying to the E. of Seringapatam. One of the veins, called the Elliot lode, has been proved to a depth of 60 feet, and contained free gold accompanied by arsenical and iron pyrites.

BELLIBETTA (12° 38′ : 76° 29′ 30″). An outlying band of Dharwar schists about eight miles in length. Numerous old workings were seen, especially on Bellibetta hill, and the indications of gold were decidedly favourable (**596**—34, 20).

CHINKERE (?). Balaji Rao (**68**—5, 152) notes the occurrence of an auriferous reef about half a mile to the E. of the ruined village of Chinkere.

HOLGERE, VALGERE, or WOOLAGIRI (12° 4′ 30″ : 76° 40′). Very small reefs and old workings were noted by Foote (**596**—34, 22), and poor results were obtained by washing. According to Bosworth-Smith (**175**—2), there is a considerable body of ore, with an average value of 4 dwt. of gold to the ton, but it appears to pinch out below a depth of 116 feet.

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HONNABETTA (12° 47′ : 76° 48′). Good washings of gold were obtained at the extreme north end of the outlier (**596**—34, 55).

HONNEMUDA (12° 40′ : 76° 47′). Extensive gold workings, along a ridge of Dharwar schists to the N. of the village, are mentioned by Attwood (**50**, 643).

KALINGANAHALLI (12° 58′ : 76° 54′). Good washings are reported, but no reefs of any size were seen (**596**—34, 55).

KARIMUDDENHALLI (12° 12′ : 76° 26′). NADAPANHALLI (12° 15′ 30″ : 76° 26′ 30″). SONNAHALLI (12° 11′ 30″ : 76° 28′ 30″). These are small outlying patches of Dharwar schists, situated about 14 miles to the W. of Mysore city. Old workings are very numerous in each case, but the results of washings were not encouraging (**596**—34, 21).

Shimoga.—HONNAGUDDA (13° 51′ : 75° 46′). Gold was found by Sambasiva Iyer (**1548**—1), generally distributed through the soil.

HONNAHATTI (13° 46′ : 75° 43′ 30″). Washings in a small stream draining the south side of Honnahatti hill gave very fine shows of gold. The schists are traversed by well marked quartz veins, with extensive old workings (**596**—34, 47).

HONNALI (14° 14′ 30″ : 75° 43′). This was considered by Foote to be a very promising gold field. Gold is generally distributed through the soil over a wide area on either side of the Nyamti (Hirehalle) R. Numerous quartz reefs were observed between the villages of KUDRIKONDA (14° 8′ 30″ : 75° 36′) and PALVANHALLI (14° 6′ : 75° 38′), and one of these, called Turnbull's reef, had been proved by deep prospecting to be richly auriferous (**596**—22, 197 ; —34, 46).

Tumkur.—CHIKNAYAKKANHALLI (13° 25′ : 76° 41′). Old workings were seen on Honnebagi hill, 2 miles to the S. W. of the town, but are not extensive. Washings in the streams flowing from the hill gave favourable indications of gold (**596**—34, 54).

JAVANHALLI or JAVANGONDANHALLI (13° 50′ : 76° 48′ 30″). Wetherell (**1915**—9, 34) states that numerous old gold workings are situated along a band of Dharwar schists, which has been traced for a distance of 62 miles, passing northwards by Javanhalli into the Chitaldroog district. The most extensive workings occur to the south of ANNESIDRI (13° 51′ : 76° 46′ 30″). Gold is obtained from many of the streams draining the Dharwar area.

NORTH-WEST FRONTIER PROVINCE.

In **Bajaur** and **Swat** gold is washed from the bed of the Panjkora and Swat rivers. According to Raverty (**1463**—2, 331), the gold is

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collected by placing sheep skins in the bed of the river, in order that the particles of gold may become entangled in the fleece.

Hazara.—Lalo Gali (34° 16′ : 72° 54′). Gold is washed from the gravels of the Indus above this village, according to Middlemiss (**1219**—17, 251, 287).

Kohat.—Zertangi (33° 17′ : 71° 36′). Wynne (**1975**—15, 241) states that gold is said to be washed from the sand of the Teri R. during the rains.

PUNJAB.

Attock.—Indus R. Jameson (**931**—3, 221) says that gold washing is practised generally along the Indus between Attock and Kalabagh. The town of Makhad (33° 8′ : 71° 48′) is especially mentioned by Fleming (**591**—3, 681) and Verchère (**1839**—2, 103) as the most important locality. The process here, as elsewhere in the Punjab, consists in filtering the sand and gravel through a grass sieve into a trough or cradle, in which concentration of the black sand associated with the gold is effected by repeated washing. The concentrates are then treated with mercury in a shallow wooden dish, and the amalgam is heated over a fire of cowdung, the mercury being lost. The yield is said to be from 3*d.* to 4*d.* a day.

Sohan R.—Gold washing in this river and its tributaries, the Ankur and Gabir, is described by Fleming (**591**—3, 681; —5, 354) and Verchère (**1839**—2, 103). The principal localities mentioned are Naka (32° 56′ 30″ : 72° 32′ 30″) on the Gabir; Taman (33° 0′ : 72° 10′) and other villages lying above it on the Ankur; and Multan (33° 2′ : 72° 4′) and Trap (33° 3′ 30″ : 71° 58) on the Sohan. The average annual production during the years 1844 to 1846 was about 112 oz. (**B.** 211).

Gurgaon.—Sohna (28° 15′ : 77° 8′). Hacket (**730**—4, 249) was informed that small quantities of gold are obtained after the rains from water-courses at the base of a hill situated at the back of the town. He presumes that the gold is derived from a band of schists included in the quartzites of which the hill is composed (**B.** 204).

Jhelum.—Bunhar R. Small quantities of gold are said to be obtained from the sands of this river, according to Wynne (**1975**—10, 86) and Bowring (**183**—1, 57). The revenue derived from the industry was about Rs. 225 annually (**B.** 211).

Kahan R.—Vicary (**1845**—6, 39) mentions the occurrence of gold in the bed of the river between the Rotas and Bukrala passes.

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All these rivers, the Indus excepted, drain the northern slopes of the Salt Range, an area occupied entirely by sandstones and pebble beds of lower Siwalik (Tertiary) age. The gold therefore has a doubly derivative origin.

Kangra.—Gerard (**650**—3, 263) alludes to the practice of gold washing in the Sutlej and other rivers in Kanawar.

The process of gold washing in the Bias R. between RAI (32° 0′ : 75° 55′ 30″) and MIRTHAL (32° 7′ : 75° 41′) has been described by Abbott (**3**—5). The yield is said to be at the rate of about 13 grains to the cubic yard. Calvert (**265**—2, 21) also mentions gold washing at SAMSI (31° 53′ 30″ : 77° 12′), higher up the river (**B.** 211).

Simla Hill States.—Colebrook (**337**—4, 127) says that small quantities of gold are obtained in the bed of the Sutlej R. at JAURI (31° 19′ : 77° 2′ 30″) in Suket.

Sirmur.—GUMTI (30° 35′ : 77° 13′ 30″). A detailed description of the process of gold washing in the Gumti R., a tributary of the Markhanda, has been given by Cautley (**292**—4). A single trough is said to yield in some cases gold to the value of Rs. 2 a day. It is also said to be obtained at Karrar (?) on the Markhanda (**B.** 212).

The average annual production of gold in the Punjab, during the five years 1909 to 1913, was 135·23 oz. In 1914 it rose to 249·98 oz., but declined to 149·59 oz. in 1915.

RAJPUTANA.

Sirohi.—ROHIRA (24° 37′ : 73° 1′ 30″). Traces of gold were detected by Major Hughes (*see* Griesbach, **708**—31, 45) in pyritous schists at this locality, associated with copper ore.

TIBET.

Extensive and richly productive gold fields are known to be worked in Western Tibet, but no scientific account of them has yet been published, nor has the source of the gold, which appears to be entirely alluvial, been ascertained. The following are the chief localities mentioned by the explorers that have approached them from the direction of India :—

DABA (31° 12′ : 79° 55′). Gold washing is carried on along the Upper Sutlej to the north of this place, according to Moorcroft (**1245**—1, 436).

MANASAROWAR LAKE (30° 40′ : 81° 30′). Strachey (**1717**—15, 394) mentions gold diggings on the shore of the lake.

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PALLO LETOK (34° 45′ : 82° 30′). Extensive gold diggings are mentioned by Rawling (**1461**—1, 418).

THOK DAURAKPA (32° 10′ : 85° 15′). An account of these mines, by a native explorer, has been published by Trotter (**1807**—2, 102). The gold is said to occur in a hard rock, which is pounded into fragments before being washed; but whether a quartz vein or merely frozen gravel is meant does not appear from the description.

THOK JALUNG (32° 24′ 30″ : 81° 37′ 30″). The gold diggings here were visited in 1867 by a native explorer, whose account of them has been published by Montgomerie (**1243**—5, 153). A trench about a mile in length and 25 feet in depth had been excavated and the gold was recovered by a rude system of hydraulic sluicing. The yield is said to have been very large, and occasionally nuggets, weighing as much as 2 lbs., were found. In spite of the intense cold the miners preferred to work during the winter, when the freezing of the soil rendered the sides of the excavation less liable to fall in. Several other gold fields of the same description were seen by the Pundit in the course of his journeys in this region (**B.** 213).

Summaries of the information available on the subject of the Tibetan gold fields have been given by Atkinson (**48**, 18), Lock (**1082**, 461), and Maclaren (**1134**—8; —11, 228).

In Central Tibet extremely minute flakes of gold were obtained by Hayden (**793**—12, 190) from the gravels of the Tsangpo near CHAKSAM (29° 20′ : 90° 44′). The total yield was found to be little more than $\frac{1}{4}$ grain per ton of gravel. Small quantities of thorianite and monazite are associated with the gold.

UNITED PROVINCES.

Almora and Garhwal.—The following rivers are specially mentioned as carrying gold:—

ALAKNANDA.—The process of gold washing, which is similar to that practised in the Punjab, has been described by Moorcroft (**1246**. Vol. I, 7). Henwood (**825**—1, 3) says that gold is obtained, but in small quantities only, at CHITAWA PIPAL (30° 16′ : 79° 14′).

GANGES.—The river is said by Atkinson (**48**, 18) to be auriferous as far as LACHMAN JHULA (30° 8′ : 78° 23′).

GUMTI or GOMATI.—Stephens (**1694**—2, 411) mentions the occurrence of gold in small quantities in this river. It is supposed to be derived from quartz veins in the neighbourhood of GWALDRUM (30° 0′ : 79° 38′) at the head of the stream. A little gold is also said to occur in the PANAR R., which drains a granitic area about DEBI DHURA (29° 25′ : 79° 55′ 30″).

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PINDAR.—The occurrence of gold in this river above KARN PRYAG (30° 15′ 30″ : 79° 17′) is mentioned by Henwood (**825**—1, 3) and Stephens (**1694**—2, 411).

RAMGANGA.—This river is said to be auriferous below its junction with the SONA (29° 33′ : 78° 48′). The occurrence of gold in the latter river is mentioned by Herbert (**827**—6, 236; 828, 757), Ravenshaw (**1462**, 265), and Lawder (**1040**—1, 88). According to Middlemiss (**1219**—10, 138), washing is carried on during the rains, and the amount obtained is trifling. Ravenshaw (*l. c.*) also mentions gold washing in the KOH R., another tributary of the Ramganga issuing from the hills to the E. of NAGINA (29° 27′ : 78° 30′), and in all the streams to the east as far as the DHELA (29° 25′ : 79° 4′). The gold of all these streams is derived from sandstones of middle Siwalik age (**B.** 217).

During the five years 1909 to 1913, the average annual production of gold in the United Provinces was 5·94 oz. For the years 1914 and 1915, the quantities recorded are 5·75 and 7·37 oz. respectively.

GRANITE *see under* **BUILDING MATERIALS.**

GRAPHITE.

AFGHANISTAN.

Graphite is included by Drummond (**504**—2, 92) among the productions of Northern Afghanistan. A specimen obtained by him is said to have been brought from the Koh-i-Daman, to the N. of Kabul (**B.** 54).

TOR SAPPER (34° 10′ : 71° 11′). Griesbach (**708**—21, 90) has recorded the presence of numerous graphitic layers in a series of micaceous and talcose shales, on the northern side of the Tor Sapper range, north of Landi Kotal.

BIHAR AND ORISSA.

Kalahandi.—Deposits of graphite occurring at the following localities have been described by Walker (**1872**—3, 14) :—

DENSURGI (20° 11′ : 83° 32′). Several bands of graphite in granitoid gneiss were observed in watercourses half a mile to the N. of the village, varying in width from about 18 inches to 2 yards. In some cases the graphite is mixed with carbonate of lime. An average sample yielded 65·22 per cent. C.

KOLADI GHAT (19° 56′ 30″ : 83° 26′). In a pit about 200 yards W. of the 168th mile post from Raipur on the road to Parvatipur,

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graphite of fair quality, forming a band from 12 to 20 inches wide, was found. It appeared to increase in width at the bottom of the pit, which was about 15 feet deep.

A sample from Densurgi examined at the Imperial Institute (*see* Dunstan, **514**—7, 43) was pronounced to be of inferior quality, and unsuitable for the manufacture of crucibles.

An output of 16 tons from this State was recorded in 1915.

Sambalpur. } —Ball (**71**—45, 53) has recorded the occurrence of
(Patna). }
impure graphite in gneissose schists at DARAMGARH (20° 24′ 30″ : 83° 18′) and DOMAIPALI (20° 49′ : 83° 4′ 30″).

Samples of graphite from this State were examined at the Imperial Institute in 1905 (*see* Evans, **555**—13). The best of these are said to have come from MARNA, 2 miles to the W. of PATNA (20° 42′ 30″ : 83° 12′), and were found to be not sufficiently pure for crucible making.

BURMA.

Henzada.—Small deposits of impure graphite, due to the alteration of carbonaceous shales by intrusive masses of serpentine, were observed by Stuart (**1723**—9, 264) to the W. of WADAWKWIN (17° 42′ : 95° 3′ 30″) and KYIBIN (17° 44′ : 95° 3′). The deposits are said to be of no economic value.

Mergui.—A substance resembling coarsely foliated graphite, described by Piddington in 1847 (**1405**—24) under the name of 'Tremenheerite,' was obtained by Tremenheere in the neighbourhood of THERABWIN (12° 18′ : 99° 3′) on the Great Tenasserim R., where it is said to occur in abundance. In Tremenheere's report on the discovery (**1802**—3) the substance is referred to as 'wad,' or amorphous manganese ore; but on analysis it proved to be a carbonaceous mineral, containing 85·7 per cent. C. The best specimen came from the Tagu stream, about 5 miles above Therabwin.

Ruby Mines.—Minute flakes of graphite are freely disseminated through the crystalline ruby-bearing limestones of this district, and in some places the mineral is concentrated into lenticular beds, developed along the line of contact of the limestones with scapolite gneiss. Some deposits of this nature, occurring at a spot about 4 miles to the S. W. of WABYUDAUNG (22° 52′ : 96° 9′), were opened up about the year 1900 by the Burma Ruby Mines Co., but were found to be deficient both in quality and quantity. Similar deposits

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also occur on a ridge about 5 miles to the N. E. of KYAUKGYI (22° 59′ : 96° 9′), to the N. of WABYUDAUNG (La Touche, MS. notes).

Toungoo.—Mason (**1186**, 10) records having seen fine specimens of graphite from the KANNI R., 20 miles to the N. E. of Toungoo, where it is said to occur in abundance.

MADRAS.

Godavari.—PERAKONDA (17° 33′ 30″ : 81° 28′ 30″). As described by Rowe (**1526**), graphite occurs here in veins from $\frac{1}{4}$ inch to a foot in thickness between bands of quartzose and garnetiferous schists, also in lenticular masses up to 4 feet in diameter. The rocks are greatly faulted, and the larger bodies of graphite occur between the fault planes.

Kistna.—BEZWADA (16° 31′ : 80° 40′). Graphite was observed by King (**987**—12, 160;—18, 263) sparingly distributed through bands of quartzose rock in the crystalline area close to the town (**B.** 53).

Tinnevelly.—Cullen (**397**—4) has recorded the occurrence of graphite in lumps the size of a small egg, in kankar deposits at TINNEVELLY (8° 43′ 30″ : 77° 45′). It was also found by Elliot (**540**—1) at PAPANASSAM and VIKERSINGAM (8° 43′ : 77° 25′)in crystalline limestone and gneiss, but in minute quantities (**B.** 53).

Travancore.—The discovery of graphite in Travancore is due to Cullen, who reported (**397**—4) its occurrence near TRIVANDRUM in 1840. Elliot (**540**—1, 216) also found small quantities occurring as scales in gneiss at KAVIATAN KUDAL and KULATORI in the same neighbourhood. At a later date Cullen described (**397**—7) prospecting operations undertaken by himself at PANILAL, a village about 10 miles to the N. E. of Trivandrum. The graphite is said to have occurred in a lateritic matrix formed by the decomposition of gneiss *in situ*. About $1\frac{1}{4}$ tons of the material were raised, and from this 1,000 lbs. of pure graphite were extracted and reported on favourably by Royle (**1529**—6), though samples sent to England were considered to be too gritty for use (**B.** 51).

In the reports of the State Geologists, Messrs. Chacko and Masillamani, for the years 1907 to 1911, reference is made to a number of localities at which graphite has been found, and to the prospecting operations of the Morgan Crucible Co., by whom the deposits of Travancore have been mined for several years. In some cases,

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however, the reports give no clue to the position of the localities, and it has not been possible to identify all of them. Those mentioned are :—

AMANAD, 4 miles S.-W. of Karungal. The mineral is said to be impure and gritty (Masillamani, **298**, 23).

ARUMANALLUR (8° 19′ : 77° 28′). A vein of no great width, with several branches, occurs in decomposed charnockite, following the strike. It has been proved to a depth of 50 feet. The graphite is of good quality (Masillamani, **298**, 11).

ARAMBOLY (8° 15′ 30″ : 77° 35′). Graphite of fairly good quality occurs on the Poigay hills, about 3 miles to the N. W. of the village (Masillamani, **298**, 30).

ATTAPALAM, in Eraniel Taluk. Graphite is exposed over a total width of 250 feet at the junction of granulite with Warkalli beds. The deposit is probably of a lenticular nature (Masillamani, **1183**, 4).

ATTUNGAL (8° 42′ : 76° 52′ 30″). Mentioned by Chacko (**298**, 79).

AVANNESSWARAM (9° 1′ 30″ : 76° 55′). A vein occurs in garnetiferous gneiss (Chacko, **298**, 67).

KARUNGAL ; in Eraniel Taluk. Graphite is said to have been found by the villagers when digging a reservoir (Masillamani, **298**, 23).

KINPALLIKONUM ; Charayinkil Taluk, between the 4th and 5th mile-stones on the road from Attungal to Venjaramud. Graphite occurs in a vein of decomposed felspar in garnetiferous gneiss. The breadth of the vein is about 90 feet (Masillamani, **298**, 12).

KOLACHEL (8° 10′ 30″ : 77° 19′ 30″). Mine opened by the Morgan Crucible Co. (Masillamani, **298**, 25).

MAMALAI ; in Peermade. A vein has been partly opened up. Specimens from the pit are very gritty (Chacko, **298**, 67).

MELMADANGU.
PERALIMUTTAM. } On the Thodupuzha R., to the S. of VAZHACULAM. Numerous large veins are exposed on lateritised hills near these villages (Chacko, **297**—1, 9).

MUNNUMBUR (8° 44′ : 76° 50).
PATHANAPURAM (9° 5′ 30″ : 76° 55′ 30″).
PUNALUR (9° 1′ : 76° 59′ 30″). } Mentioned by Chacko (**298**, 79).

SHORLACODE (8° 20′ : 77° 26′). A vein of good quality and of fair dimensions (Masillamani, **298**, 23).

The graphite deposits of Travancore are stated by Holland (**259**—50, 51) to occur under conditions similar to those of Ceylon,

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which is geologically a continuation of the charnockite series and associated rocks of Southern India. The graphite of Ceylon is regarded by Weinschenk (**1910**) as of igneous origin, a conclusion in agreement with the observations of Holland (**859**—31, 152; —34, 172) on the charnockites and elæolite syenites of India.

Owing to the difficulty of working at increased depths, the mining of graphite in Travancore has become unprofitable, and operations were suspended in 1912. For the five previous years the average annual output was 3,349 tons. The most productive mine is said to have been situated at VELLANAD (8° 34′ : 77° 7′) in the Nedamangad Taluk.

Vizagapatam.—Graphite is of common occurrence along the eastern border of the Hill Tracts of Vizagapatam, where it appears to be associated with charnockites, as in South India, but the quantity available has as yet proved insufficient to repay the cost of mining. The principal deposits are situated in the neighbourhood of SALUR (18° 31′ : 83° 16′), according to King (**987**—33, 155) and Balfour (**69**—2, 239). Carmichael (**285**, 154) also mentions its occurrence near KASIPURAM (18° 13′ : 83° 11′). Specimens examined by Royle (**1529**—6) were pronounced to be of very inferior quality (**B.** 53).

An output of 259 tons from the district was recorded in 1910, and of 54 tons in 1911. Since the latter year the returns have been blank.

PUNJAB.

Gurgaon.—SOHNA (28° 15′ : 77° 8′). Hacket (**730**—4, 249) mentions an occurrence of graphite in a band of schists, in quartzite forming a hill at the back of the town. The quantity appeared to be small. Specimens from this locality analysed by Thompson (**1770**) contained 78·45 per cent. C, and 17·2 per cent. of earthy matter.

The same authority (*see* Baden-Powell, **60**—1, 17) says that the graphite occurs in a gorge on the eastern side of the hill, and forms a bed from 18 to 24 ins. thick, exposed for about 30 yards. The quality is very variable, some portions being hard and compact, while others are soft and easily reduced to powder.

RAJPUTANA.

Ajmer-Merwara.—An output of 54 tons of graphite from Merwara was reported in 1915, but the locality of the deposit is not stated.

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SIKKIM.

A vein of graphite, averaging 13 inches in thickness, was discovered in the course of prospecting operations conducted by Messrs. Burn and Co. at about half a mile to the N. of the road between TSUNTANG (CHEUNGTONG, 27° 36′ : 88° 41′) and LACHEN (27° 44′ : 88° 35′). Bulk samples are said to have given a return of 93 per cent. of graphite (**862**, 98).

Graphitic layers are not uncommonly found among the slates of the Daling series in the valleys of the Great Rangit R. and its tributaries, but are of no economic value.

UNITED PROVINCES.

Almora.—The occurrence of graphite in the neighbourhood of Almora was first noted by Herbert (**827**—6, 230; —10, cxxvii) in 1829. It was found in nodules from 1 to 3 inches in diameter, weathered out from a band of mica schists on the ridge between Almora and Kalimati, 3 miles to the north. Specimens analysed by Prinsep (**1436**—8, 280) contained 71·6 per cent. of carbon.

In 1850, pits were opened by Drummond (**504**—3) at KALIMATI, GARGOLI near BALT (29° 38′ : 79° 45′), and PULSIMI (29° 35′ 30″ : 79° 45′). At the last named place about 15 tons were extracted, and samples were favourably reported on by Rose (*see* Atkinson, **48**, 32) : but in a subsequent report (**1529**—6) Royle pronounced the mineral to be economically valueless (**B.** 54).

The occurrence of graphite in this neighbourhood has also been noticed by the following writers :—

1851. Strachey (**1717**—8, 299). A brief note on the occurrence.

1856. Sowerby (**1679**—2, 8). The graphitic schists were traced for a distance of about 15 miles. The best specimens were obtained at PATHAMI (? PULSIMI), but in very small quantities.

1864. Medlicott (**1197**—5, 180). States that the best graphite is developed along faults or lines of strain in the schists.

1869. Lawder (**1040**—1, 87). Mentions the occurrence of graphite at KALIMATI and on the spur of BANINI DEVI facing Almora on the road to Lohughat.

1871. Henwood (**825**—3, 40). Records the occurrence of graphite near DOL (29° 29′ 30″ : 79° 49′ 30″), and on both banks of the SUAL R., to the S. E. of Almora.

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1878. Hughes (**890**, 183). Notes the occurrence of a bed of impure graphite at the crossing of the LADHAR R. (29° 53′ : 79° 50′) on the road from Bagesar to Kapkot.

GYPSUM.

AFGHANISTAN.

Gypsum is mentioned by Griesbach (**708**—4, 59) as common in the Gaj (Miocene) formation, where it occurs in beds, lenticular masses, and veins. Also in the younger Tertiary rocks, and as forming considerable deposits among the post pliocene gravels and clays of the plains. It is found in thick beds, about 3 feet below the surface, near KANDAHAR, where it was largely used, according to Hutton (**900**—8, 585, 604), for plastering buildings.

The town of GHAZNI (33° 33′ : 68° 26′) is said by Vigne (**1846**—3, 126) to be built at the foot of a ridge composed of gypsum (**B.** 452).

In KAHMARD (35° 20′ : 67° 40′) and SAIGHAN (35° 10′ : 67° 45′) beds of gypsum occur, according to Hayden (**793**—22, 36, 37), at two distinct horizons; *viz.*, beneath limestones of upper Cretaceous age, and among lower Tertiary shales.

BALUCHISTAN.

In **Jhalawan, Sarawan,** and **Mekran**, the Tertiary clays and shales at all stages, when but slightly disturbed, contain numerous crystals of gypsum, according to Vredenburg (**1854**—36, 209), but no continuous masses of the mineral were met with.

Kachhi.—Blanford (**148**—73, 231) mentions the occurrence of pure white gypsum in the hills to the S. E. of PULEJ (29° 1′ : 68° 22′ 30″) and N. by E. of SHAHPUR (28° 43′ : 68° 25′). It is found in irregular masses up to a foot in diameter at the base of the lower Siwaliks, and is said to be well adapted for ornamental purposes. Thin veins of gypsum, filling cracks in the upper Siwalik rocks surrounding the Kachhi, were also observed by Blanford. Vicary (**1845**—3, 261) also mentions its occurrence under similar conditions near UCH (28° 39′ 30″ : 68° 40′).

Quetta-Pishin.—Considerable quantities of gypsum are obtained from the GHAZIABAND PASS (30° 19′ : 66° 48′) and used for building purposes in Quetta. It is described by Griesbach (**708**—4, 20) as occurring in lenticular masses, veins, and beds, in a formation identified by him with the Gaj group of Sind; but according to Blanford (**148**—73, 180), it is found in fibrous masses filling cracks in Siwalik sandstones and clays.

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Sibi.—Frequent mention is made by Blanford (**148**—73) of the occurrence of beds of gypsum, from 5 to 10 feet in thickness, among Eocene shales in the Bugti hills.

Near KHATTAN (29° 34′ : 68° 31′) four distinct beds of gypsum, ranging up to 8 feet in thickness, were observed by Oldham (**1324**—32, 109). It was also seen near SPINTANGI (29° 55′ : 68° 5′), forming a band 4 feet thick in nummulitic limestone.

Oldham (**1324**—37, 29) has noted the occurrence of gypsum in thick beds, one measuring 50 feet, near MAMAND (29° 39′ : 68° 43′) in the Mari hills.

BHUTAN.

The occurrence of thick beds of gypsum in the valley of the KANGRA CHU (26° 54′ : 91° 6′) has been recorded by Pilgrim (**1406**—28).

BOMBAY.

Cutch.—The shales of the Jurassic, sub-Nummulitic, and Tertiary groups contain large quantities of gypsum, the most highly gypsiferous being the sub-Nummulitic group (Wynne, **1975**—11, 90). The mineral is generally translucent, and occurs in blocks several inches in length (**B.** 451).

The following localities are specially mentioned :—

On an outlying patch of Tertiary rocks on the Runn, E. of ADESAR (23° 33′ : 71° 2′).

Between ADKUI (23° 24′ : 70° 34° 30″) and BADARGARH (23° 28′ : 0° 41′).

Near CHITRORE (23° 24′ : 70° 44′).

About 2 miles to the S. W. of MHURR (23° 32′ : 69° 0′ 30″).

E. and N. E. of UMARSAR (23° 44′ 30″ : 68° 54′).

Kathiawar.—Fedden (**569**—6, 134) mentions the occurrence of gypsum in small tabular masses and crystals in some of the Tertiary beds. It was found, though not in great quantity, in the Bhavnagar State on the eastern side of the peninsula ; also near NANDANA (22° 8′ : 69° 21′) and on the hills about KURANGA (22° 8′ : 69° 13′ 30″) in the west.

According to Adye (**11**, 210), crystals and veins of selenite occur in some quantity in calcareous clays of the Gaj group, near the villages of BHATIA (22° 6′ : 69° 20′), RAN (22° 11′ : 69° 23′ 30″), and VIRPUR (22° 15′ : 69° 22′ 30″).

Rewa Kantha.—In the Rajpipla State, Bose (**173**—23, 186) met with gypsum in Tertiary clays at BHILOD (21° 36′ : 73° 16′)

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and DODVADA (21° 32′ : 73° 9′). The mineral was rather earthy, and did not appear to occur in large quantities.

Sind.—Gypsum of tolerable purity occurs abundantly, according to Blanford (**148**—63, 195), in the upper parts of the Gaj (Miocene) group in the Khirthar range. Two beds were noted in the section exposed on the GAJ R. (26° 52′ : 67° 20′), with a thickness of 3 to 4 feet, and similar beds are frequently met with to the northwards. Some gypsum is found in the Ranikot group at the base of the Eocene, but the quantity is small (**B.** 451).

CENTRAL INDIA AGENCY.

Dholpur.—A small isolated deposit of selenite, occurring midway between the villages of KATHUMRI (26° 41′ : 78° 6′) and GHURIA-KHERA (one mile to the W.N.W.), on the Chambal R., has been described by Heron (**830**—3). The selenite is found in crystals of a maximum length of 1½ inches, scattered sparsely through a carbonaceous layer, a foot thick, in the older alluvium. It is said to be used medicinally.

Rewah.—A unique occurrence of gypsum in Vindhyan rocks (Sirbu shales) at SATNA (24° 34′ : 80° 53′ 30″) has been recorded by Fermor (**577**—8). The mineral was obtained from a boring for water, at depths between 200 and 338 feet from the surface. It occurs in layers a quarter to five-eighths of an inch in thickness, parallel to the bedding planes of the shales.

MADRAS.

Chingleput.—Small quantities of gypsum in the form of selenite crystals are obtained from the clayey estuarine beds to the north of Madras (Foote, **596**—8, 132). The occurrence of these crystals over a large area in the neighbourhood of MONEGUR CHOULTRY, near Madras, and at KATHIWAKAM or ENNUR (13° 13′ : 80° 23′) is especially mentioned by Hunter (**894**—2 ; —8 ; —14).

Nellore.—Large quantities of selenite crystals were noted by Foote (**596**—17, 93) in marine clays at SANTARAVUR (15° 48′ 30″ : 80° 19′) on the Buckingham Canal. The crystals are said to be far larger and of greater purity than those obtained from similar clays near Madras (**B.** 451).

Trichinopoly.—Blanford (**147**—8, 214) states that gypsum occurs abundantly, in the form of fibrous plates and concretions, among

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the Cretaceous rocks in many parts of the district. It is said to be most abundant in the Utatur group, especially in Belemnite clays to the E. of UTATUR (11° 4′ 30″ : 78° 55′), and in unfossiliferous clay to the N. E. of MARAVATTUR (11° 13′ : 79° 1′).

NORTH-WEST FRONTIER PROVINCE.

Dera Ismail Khan.—A zone composed of alternating bands of dolomite and gypsum, from 450 to 500 feet in thickness, was noted by Wynne (**1975**—28, 279) in a cliff section near SAIDUWALI (32° 12′ : 71° 6′), at the southern end of the Khasor range.

Plates of selenite also occur in the Jurassic clays exposed on the southern scarp of the Sheikh Budin hills (*l. c.*, 286) near PANIALA (32° 15′ : 70° 56′ 30″); and at the base of the same scarp an exposure of the 'salt marl' was observed by Verchère (**1839**—2, 17), with some massive beds of gypsum.

Hazara.—The occurrence of gypsum, forming beds or veins in the Slate series, has been recorded by Middlemiss (**1219**—17, 287). An isolated small exposure was noted at DOWATTA (34° 17′ : 73° 30′ 30″), and the discontinuous outcrop of a bed or vein between the villages of BIJORA and BARI-KA-BUGLA, passing along the east slope of the hill marked 6,462 feet (34° 10′ : 73° 30′), where it reaches a thickness of 100 feet.

Kohat.—An important development of gypseous beds in the upper portion of the Eocene nummulitic series has been described by Wynne (**1975**—15, 149).

The beds are exposed in all the ridges extending from the neighbourhood of BAHADUR KHEL (33° 11′ : 71° 1′) eastwards to the Indus, covering an area of about 50 miles in length by 20 miles in maximum breadth. The gypsum occurs in discontinuous masses, which occasionally attain a thickness of at least 200 feet, and is associated with bands of clay, and in the lower portion with black shales strongly impregnated with petroleum. The colour is usually white or grey, but sometimes deep red, owing to the presence of iron (**B.** 452).

Sherani.—A band of gypsiferous shales, alternating with beds of limestone, occurring at the base of the upper Nummulitic group, was traced by La Touche (**1034**—20, 86) from the Toi R. in the south of the district to the Zao defile in the north, a distance of 24 miles. In a measured section at ZOR SHAHR (31° 42′ : 70° 8′ 30″), about the centre of the band, 12 beds of gypsum were counted,

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varying in thickness from a foot to 11 feet 7 inches, with an aggregate thickness of 50 feet. Nodules of gypsum also occur in the associated limestones.

PUNJAB.

Jhelum, Shahpur, and Mianwali (Salt Range).—Gypsum occurs in enormous quantities, both in the form of selenite crystals and in massive beds of considerable purity and variety of colours, in association with the 'Salt marl' which extends along the southern base of the Salt Range from the neighbourhood of JALALPUR (32° 39′ 30″ : 73° 28′) in the east to KALABAGH (32° 58′ : 71° 37′), on the western bank of the Indus. It appears to have been first brought to notice in 1843 by Jameson (**931**—3, 197), who records the existence of thick masses of a pure white colour near Jalalpur and other places along the base of the range. General accounts of its mode of occurrence have since been given by Fleming (**591**—5, 250), Theobald (**1763**—1, 658), and Wynne (**1975**—18, 73).

Very little use has hitherto been made of the Salt Range gypsum. It is occasionally mixed in a powdered state with mortar; and a compact variety occurring near SARDI (32° 41′ : 72° 47′) has been quarried and turned to form plates and other utensils. The selenite crystals are also collected and sold for medicinal purposes (**B.** 452).

The origin of the gypsum has been discussed by Holland (**859**—2; —4) with reference to a hypothesis, put forward by Middlemiss (**1219**—14, 26), that the 'Salt marl' may owe its peculiar position among the surrounding rocks to some kind of volcanic agency. The presence of inclusions of anhydrite in bi-pyramidal quartz crystals imbedded in the gypsum, and the intimate association of the latter in many instances with anhydrite, lead to the conclusion that the gypsum is not of aqueous or sedimentary origin, but that it results from the addition of water to anhydrite, which may have been produced by the action of super-heated water charged with sulphuric acid on limestone or dolomite.

Kangra.—Gerard (**650**—3, 264) appears to have been the first to note the existence of gypsum in the lower Spiti valley. In 1841 Hutton (**900**—5, 207) gave a description of the deposits, which he supposed to have been accumulated on the bed of a salt lake filling the entire valley; but Mallet (**1159**—1) has shown that they have no connection with the alluvium of the valley, but are due to the action of thermal waters containing sulphuric acid in solution on limestone.

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The deposits are of considerable extent and thickness, and the gypsum is said to be of snowy whiteness and crystalline texture, eminently suitable for ornamental purposes, or for the manufacture of plaster of Paris (**B.** 453).

The largest of the masses noted by Mallet is situated on the left bank of the Spiti R., opposite SHALKAR (32° 0′ : 78° 37′). Smaller masses were seen near the CHANGO PASS, on the same side of the river, and in the main valley between Shalkar and Huling (32° 4′ : 78° 36′). In addition to these localities, Hayden (**793**—9, 101) has recorded the existence of immense masses and thick beds between the LIPAK and YALUNG rivers, to the S. of Shalkar, and in the valley of the GYUNDI R. (32° 20′ : 77° 54′) in upper Spiti.

Rawalpindi.—Middlemiss (**1219**—17, 287) records the occurrence of gypsum at various places in the Kuldana series, or passage beds between the nummulitic limestone and the Murree sandstone. CLIFDEN near Murree (33° 54′ : 73° 27′), and the gorge W. of DUNGA GALI (34° 4′ : 73° 30′), are the localities specially mentioned.

RAJPUTANA.

Marwar (Jodhpur)—Beds of impure gypsum of considerable extent occur in several places among the sand hills of the Rajputana desert, occupying the basins of desiccated salt lakes. Such deposits have been specially noted by Forbes (**599**, 30) and La Touche (**1034**—28, 43) near KURLO, MADPURA, and SHAOKAR, between BARMER (25° 45′ : 71° 25′) and the Luni R. The gypsum is used to some extent for building purposes, and when burnt as plaster for lining wells.

The average annual production from a deposit of this description situated to the N. N. W. of NAGAUR (27° 13′ : 73° 48′), was 4,905 tons during the quinquennial period 1909 to 1913. In Bikanir, during the same period, the average annual output was 11,251 tons.

UNITED PROVINCES.

Dehra Dun.—The nature and origin of certain deposits of gypsum, occurring among the hills to the north of Dehra Dun, was made the subject of special investigation, about the year 1830, by Herbert (**827**—5), Cautley (**292**—2), and Everest (**557**—5), all of whom recognised the secondary character of the beds, and attributed them to the alteration of carbonate of lime by the infiltration of sulphuretted water. According to Medlicott (**1197**—5, 177), nodules of gypsum occur in many places among the ferruginous

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clays of the Subathu group, and it forms irregular veins in limestones at SAHANSADHARA (30° 23′ : 78° 10′ 30″), the principal locality mentioned by Herbert and Cautley. At SALKOT, 4 miles to the north, it forms a mass about 200 feet in thickness, and large masses were also noted by Fisher (**587**—1, 194) below JERIPANI (30° 25′ 30″ : 78° 8′ 30″) on the road between Rajpur and Mussoorie. It is said to have been employed in the internal decoration of houses at Dehra Dun with some success (**B.** 453).

Hamirpur.—Small quantities of selenite are found at certain spots in the older alluvium of the Bairma R., a tributary of the Betwa, in the neighbourhood of PURAINI (25° 45′ : 79° 50′). The crystals have been formed, according to La Touche (**1034**—35), by the action of sulphuretted water on carbonate of lime disseminated through the alluvium, and are found in plastic clay at a depth of about 5 or 6 feet below the surface. The amount available is exceedingly small, but the crystals are collected and sold in Cawnpore for use as medicine.

Jhansi.—Deposits of selenite similar in all respects to those of Hamirpur have been described by Silberrad (**1632**—2) as occurring in the neighbourhood of GONTI (25° 47′ : 79° 13′) and GOKHAL (25° 46′ : 79° 20′ 30″).

Naini Tal.—The occurrence of large deposits of gypsum on the NIHAL stream, between Kaladhungi and Naini Tal, is mentioned by Atkinson (**48**, 34). According to a special report by Middlemiss (**1219**—8), the most important masses are situated about a mile to the N. of DHAPILA (29° 19′ : 79° 28′). In mode of occurrence and origin the deposits are similar to those already noted in the Dehra Dun district. The total quantity of the mineral available is estimated by Middlemiss at about 37,430 tons.

ILMENITE *see* **RARE MINERALS—TITANIUM.**

IOLITE *see under* **GEM-STONES.**

IRIDOSMINE *see* **PLATINUM.**

IRON.

The iron ores of India may be separated into two main groups in accordance with their mode of occurrence :—

(A) "Primitive" ores, forming beds or more rarely lodes, among strata which may belong to any geological formation of earlier

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date than the close of the Tertiary period. These may be subdivided into :—

(1) Pre-Cambrian quartz-hematite and quartz-magnetite schists, in which the ore is usually disposed in bands alternating with siliceous material, or is occasionally concentrated into lenticular bodies of great size and purity. These ores are most prominently developed in the Dharwarian series of Southern India and the Central Provinces, and to a less extent in the Bijawar group of Central India.

(2) Magnetite in minute particles disseminated through the crystalline rocks, including the older granites and schists, basic dykes, and the widespread flows of basalt of upper Cretaceous age known collectively as the Deccan trap. These particles, when concentrated by running water, afford in some localities a sufficient and readily accessible supply of ore to the native workers.

(3) Veins of limonite occurring along fault planes or fractures in the Cuddapah and similar formations.

(4) Bands and nodules of clay ironstone, most highly developed among the shales of the lower portion of the Indian coal measures; but also met with at higher horizons.

(B) "Derivative" or "Lateritic" ores, due to the segregation of iron oxide, carried up in solution by sub-soil water, in the superficial deposits formed by rock weathering. The process appears to require an alternation of moist and dry periods, such as are characteristic of a tropical climate, and particularly of the climate of the Indian peninsula. In certain cases, metasomatic replacement of the silica and other constituents of a rock may give rise to the formation, at the outcrop, of beds of rich ore, enclosing portions of the original rock, and retaining traces of the bedding or other structural planes. On these ores Fermor (**577**—32, 381; —39, 515) has bestowed the name 'lateritoid,' in order to distinguish them from the true lateritic ores. The lateritoid ores are chiefly associated with the Dharwarian hematite schists, but may occur at the exposed edges of beds belonging to later geological periods. They may give the appearance of an outcrop of rich ore to a bed which is perhaps only moderately ferruginous, and may thus lead to anticipations of an abundant supply, which on being tested prove to be unfounded.

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The process of iron smelting, as performed by the natives of India, is practically the same for all parts of the country, though the dimensions of the furnace and the form of blowing apparatus employed may vary in different areas. The furnace is built of clay by the smelter and his family, and is of no great capacity, the maximum yield reported for a single furnace being about 30 tons per annum; while the blast is usually supplied by a pair of leather bellows. Only the softer varieties of ore, such as can be easily reduced to powder, and if necessary concentrated by winnowing, are made use of. These are gathered from the surface or dug out from shallow pits and trenches; or, when available, are collected in the form of iron sand from the beds of streams. The ore is reduced in direct contact with charcoal, and without the addition of a flux, to a pasty mass, or 'bloom,' from which the slag is expressed by repeated hammering and re-heating; since the temperature at command is seldom high enough to bring about the complete liquefaction of the charge.

The iron produced, on account of its purity and malleability, has always been held in great estimation by the Indian blacksmiths, a circumstance that has enabled the native industry to withstand to some extent the competition of imported iron. But though its superiority is so marked that, at the time when the Britannia tubular bridge across the Menai Straits was under construction, preference was given to the use of iron produced in India, failure has attended every attempt made to carry out the native process on an extended scale under European supervision. This result has been due, however, not to any defect in the quantity or quality of the ore available, but mainly to the difficulty of procuring adequate supplies of charcoal, in consequence of the depletion of the forests in the immediate neighbourhood of the works.

The question of fuel suitable for use in blast furnaces of the European type has now been solved by the development of the Indian coal fields, and the discovery that some of the deeper seams are capable of furnishing coke of excellent quality. It has therefore become possible to establish iron works on a large scale, and this has been done in two instances where deposits of iron ore occur within a reasonable distance of the coal fields. These are the works of the Bengal Iron and Steel Co. near Barakar, established in 1889, which for many years drew their supplies of ore from the Ironstone shales of the Raniganj coal field; and those of the Tata Iron and Steel Co. at Sakchi, which have been in operation since 1911. The ore for these works is at present furnished by immense deposits of hematite situated in the State of Mayurbhanj.

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The general distribution and mode of occurrence of iron ores in India, with details of the native processes of smelting, and the history of recent developments of the industry, are dealt with in the reports and papers noted below :—

1873. Blanford (**148**—42, 391). An account of the nature and distribution of iron ore, with remarks on the native processes of smelting.

1874. Bauerman (**89**). Report on the iron ores of India.

1881. Mallet (**1159**—23). Discusses the origin of the lateritic iron ores of India.

1886. Schwarz (**1594**—3). Describes the principal iron ore deposits, with special reference to those of Barakar and the Central Provinces.

1886. Gilchrist and Riley (**658**). An account of the iron-making resources of India, compiled for the Colonial and Indian Exhibition.

1893. Holland (**859**—11). Describes the mineralogical and metallurgical characters of the ores of the Madras Presidency, their distribution and geological relations; and discusses the question of fuel supply, and the introduction of European processes of iron and steel manufacture.

1893. Turner (**1817**). Describes the native processes of smelting, with analyses of the ore and products, and discusses th efuture of the industry.

1899. Mahon (**1153**—1). Discusses the prospects of manufacturing steel at a profit in India.

1900. Anon (**35**—56). A general account of the Indian iron ores, and of attempts made to establish the industry on modern lines.

1900. Mahon (**1153**—2). Report on the distribution of coal and of iron ores in India, with a view to the establishment of iron and steel works.

1901. Schwarz (**1594**—5). A general account of the native iron and steel industry with remarks on the distribution of the ores, and a history of modern developments.

1905. Tozer (**1795**, 769). A brief account of the development of the iron and steel industry.

1907. Holland (**859**—64, 34). Discusses the prospects of establishing an export trade in Indian iron ore.

1910. Holland and La Touche (**863**). Notes on the general distribution of iron ores in India.

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1911. Lester (**1064**). Describes the native processes of iron smelting, especially those employed in Burma and the Central Provinces.

1912. Perin (**1392**). An account of recent developments of the iron industry, with special reference to the Tata Iron and Steel Works.

1912. Sahlin (**1542**—1; —2). Discusses the potentialities of India as an iron-producing country, and describes the Tata Iron and Steel Works.

1914. Bose (**171**). A general account of the iron ore deposits, compiled from the publications of the Geological Survey, with a history of recent developments of the industry.

The average amount of iron ore raised annually in India, during the five years 1906 to 1910, was 74,105 tons. In 1911, consequent upon the opening of the Tata Iron and Steel Works, the output rose to 366,190 tons, an amount approximately equal to the total production of the preceding five years. For this and the four following years the average annual output has amounted to 429,840 tons.

AFGHANISTAN.

According to Drummond (**504**—2, 82), writing in 1841, most of the iron then used in Afghanistan was smelted from iron sand collected from the mountain streams in **Bajaur**; but he also mentions (page 75) the occurrence of a bed of hematite, 30 to 40 feet in width, at the SILAWAT PASS (34° 22′ : 69° 17′). Thick beds of hematite were also noted by Lord (**1091**—2, 536) near the HAJIGAK PASS (34° 39′ : 68° 7′).

The Silawat ores are associated, according to Hayden (**793**—22, 17) with schistose hematite-quartzites and other crystalline rocks, probably corresponding to the Dharwarian series of the Indian peninsula. The Hajigak ore, on the other hand, is probably of Devonian age. It is described (*l. c.*, page 24) as forming a conspicuous band at the base of the Hajigak series, traceable from near KALU (34° 41′ : 68° 2′) into and beyond the PANJSHIR VALLEY (35° 20′ : 69° 45′). Little use appears to have been made of these ores, though Lord mentions (**1091**—2, 525) a large deserted iron mine at SUKHT-I-CHENAR, on the road to the Ghorband Pass; nor has any analysis of the ores been published (**B.** 402).

ASSAM.

Abor Hills.—Thin bands of shale with numerous nodules of clay ironstone of good appearance were observed by Coggin Brown

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(**211**—5, 253) in the bed of the Dihang R. at the GEKU crossing (28° 26′ : 95° 6′).

Khasi and Jaintia Hills.—The earliest account of the manufacture of iron in the Khasi hills was given by Jones (**956**—2, 284) in 1829, when the industry appears to have been in a flourishing condition; so much so that the establishment of iron works on a large scale at Cherra Punji was seriously advocated by Watson (**1902**—1). The method of obtaining the ore, and the native process of smelting, have been fully described by Walters (**1880**—3, 505), Cracroft (**383**—2), Yule (**1987**—1), Oldham (**1326**—8, 201), and lastly by Darrah (**420**), whose report was written in 1885, when very few furnaces were still kept at work.

The ore, in the form of magnetic iron sand, was collected by a system of ground sluicing from granite decomposed to a considerable depth by weathering. The granite is exposed over wide areas in the neighbourhood of the villages of SURARIM (25° 21′ : 91° 48′) MOLIM (25° 29′ 30″ : 91° 53′), and NONGSPONG (25° 27′ : 91° 40′), where the chief centres of manufacture were situated. The 'bloom' produced at each operation weighed from 10 to 14 lbs., but contained a large proportion of slag, which was afterwards removed by the blacksmiths. Much of the iron was exported to the plains of Sylhet, where it was in great demand for making the staple-shaped cramps used in fastening the timbers of boats (**B.** 412).

Lakhimpur and Sibsagar.—The iron industry of Upper Assam, which was of considerable importance under native rule, as described by Robinson (**1503**—1, 34) and Hannay (**760**—5), has long become extinct. The principal ores used, according to Mallet (**1159** 9, 359), were clay ironstone nodules from the coal measures, containing from 22 to 40 per cent. Fe; and impure arenaceous limonite from the Sub-Himalayan (Tipam) group. The latter variety is said to occur in unlimited quantities, but is of poor quality, the average yield being considerably less than 30 per cent. Fe. Hannay (**760**—1) mentions the existence of old excavations made in search of iron ore near JAIPUR (27° 16′ : 95° 27′), but the chief centres of manufacture were situated at TIRUGAON (26° 52′ 30″ : 94° 58′), HATTIGHAR (?) to the E. of Sibsagar, and GOLAGHAT (26° 31′ : 94° 1′). The native smiths appear to have possessed a considerable amount of metallurgical skill, since they were able to turn out guns of large dimensions as well as small arms (**B.** 412).

Large quantities of ferruginous sandstone, passing locally into sandy hematite and hematitic conglomerate, were observed by

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Smith (**1657**—2, 92) in the Mikir hills, but it is seldom that the hematite is sufficiently concentrated to afford a workable ore.

Manipur.—The ore used by the native smelters occurs, according to Oldham (**1324**—3, 239), in the form of small pisolitic nodules of limonite in swampy tracts, beneath 2 to 5 feet of alluvium. The ore bed is from 3 to 12 inches thick. The furnace is of a most primitive description, open in front, and about 18 inches in height. Gupta (**726**) states that the ore is piled into a heap with layers of straw and roasted, before being smelted.

BENGAL.

Bankura.—Everest (**557**—1, 130) mentions the occurrence of large quantities of iron ore, supposed to have been deposited by springs, at a locality 4 miles to the S. of Bankura.

Birbhum.—The indigenous iron industry appears to have been more highly developed in the Birbhum district than in any other part of India, for the furnaces were not only the largest in use, but their efficiency was, comparatively speaking, of a high order. The iron was reduced to a molten condition, and was refined by a second operation resembling puddling, in which it was converted into wrought iron. The operations have been described by Jackson (**922**) and Oldham (**1326**—2, 6). The chief centres of manufacture were MAHOMED BAZAAR (23° 59′ 30″ : 87° 38′), DEOCHA (24° 2′ : 87° 39′), DAMRA (24° 6′ : 87° 40′ 30″), and BALLIA-NARAINPUR (24° 14′ : 87° 45′ 30″). About 70 furnaces were at work in 1852, according to Oldham, who estimated the total production of unrefined iron at 2,380 tons per annum (if the furnaces were continuously worked), equivalent to about 1,700 tons of wrought iron. In addition, a certain quantity of iron was smelted in smaller furnaces by the SANTALS, an aboriginal hill people, whose operations have been described by Torrens (**1791**—2).

The principal supplies of ore were obtained from lateritic deposits at the southern margin of the Rajmahal trap area, especially those in the neighbourhood of MALLARPUR (24° 5′ : 87° 46′ 30″). These ores were made the subject of a special examination by Hughes in 1875, in connection with proposals to establish iron works in the district, the results of which are quoted by Ball (**71**—26, 243). The average yield of iron from 29 samples, collected at various localities, was 43 per cent. Phosphorus was estimated in 4 of these samples, and amounted on the average to 1·5 per cent. P_2O_5. Analyses made by Piddington in 1829 (**1405**—1), and in 1858 by Barratt

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(**80**—3), gave similar results. Two other sources of ore are mentioned by Ball (*l. c.*, 241), *viz.*, veins and nests of brown hematite, occurring in the Gondwana sandstones, which furnish the ore used by the Santals; and secondly, layers of pisolitic iron ore and nests of brown hematite, associated with the Rajmahal trap.

The first attempt made to develope the industry under European supervision dates from the year 1777, when Messrs. Motte and Farquhar were granted the exclusive privilege of manufacturing iron to the west of the meridian of Burdwan. Operations were carried on in Birbhum from 1779 to 1789, with what result is not known, but the lease was relinquished in 1795 (*see* Heatly, **801**, 545). Nothing further appears to have been done till 1855, when works were started at Mahomed Bazaar by Messrs. Mackay and Co., capable of producing 2 tons of pig iron a day. In a report on these operations by Blanford (**148**—4), it is stated that the iron was superior in quality to ordinary English pig iron, and that the supplies of charcoal, ore, and flux would be sufficient for works on a moderate scale, if careful supervision were exercised over the management of the forests. A final experiment initiated by Messrs. Burn and Co. in 1875 was abandoned after a few months' trial (**B.** 362).

Burdwan.—The iron ores of the Raniganj coal field occur in the Ironstone shale group, or middle division of the Damuda series. The estimated thickness of the group is about 1,400 feet, and its outcrop extends for a distance of about 33 miles from east to west. The ore is not equally distributed throughout, but is more abundant, according to Blanford (**148**—7, 74), in the upper part of the group, where it forms discontinuous seams or strings of nodules consisting of clay ironstone. Bands of carbonaceous ore, or 'black band', are also occasionally met with. From measurements made by Smith (**1655**—1, 76) in a shaft at BARUL, or BADUL (23° 44′ 30″ : 87° 10′ 30″), 8 miles to the N. of Raniganj, Blanford estimated the average proportion of ore at about 1-17th of the whole thickness of strata; but measurements made by Hughes (**888**—14, 25) gave one foot of ore in 10 or 12 feet of shale, and the quantity available as, roughly speaking, 200 millions of tons in every square mile.

Analyses of the ore made by Piddington (**1405**—1) and Prinsep (**1436**—8, 278) show that the proportion of iron varies within wide limits. Blanford (**148**—7, 194) quotes analyses of 29 samples from various localities giving an average yield of 38·92 per cent. Fe. Phosphoric acid, as determined by Hughes (**888**—16), occurs in amounts varying from 0·57 to 2·57 per cent., but traces only of sulphur were detected in the 7 samples examined.

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In the year 1839 a practical experiment was made by Messrs. Jessop and Co. (**945**) in smelting about half a ton of Burdwan ore, using coke as fuel, but proved inconclusive, as the iron could not be reduced to a fluid state. Several years later, proposals for establishing iron works in the Damuda valley were discussed by Oldham (**1326**—2, 9) and Baker (**67**, 489); and in 1874, following the submission of a report by Bauerman (**89**), the whole question of the resources of the Raniganj field in iron ore, fuel, and flux, was made the subject of a report by Hughes (**888**—14; —16). Works were started in the following year at KULTI, near BARAKAR (23° 45′; 86° 52′), by a private Company; but, owing mainly to insufficient capital, the enterprise proved unsuccessful, and was abandoned in 1879. From a report submitted by Schwarz (**1591**—1) in 1882, it appears that two furnaces had been erected, each capable of producing 20 tons of pig iron a day (**B.** 368).

The plant was then taken over by Government, and operations were carried on till the year 1889, when the undertaking was transferred to the Bengal Iron and Steel Company, who entirely remodelled the works, and gradually developed them until there are now three blast furnaces furnished with up-to-date equipment at work; besides foundries covering an area of about 104,000 square feet, rolling mills, etc. The average annual production of the works, during the five years 1909 to 1913, was 48,364 tons of pig iron, and 13,208 tons of castings.

On account of the high percentage of phosphorus in some of the Raniganj ores, it was found advisable to mix them with magnetic ores brought from the Singhbhum district, whereby the proportion of phosphoric acid was reduced from an average of 2·09 per cent. to about 0·50 per cent. (*see* Harris, **769**—1). More recently the use of Raniganj ore, owing to the depletion of the stocks readily available at the outcrop of the shales, has been given up, and the works are now supplied entirely with ore from Singhbhum. For this reason the quantity of iron ore raised in Burdwan has declined from a yearly average of 72,988 tons during the five years 1905 to 1909, to 9,971 tons during the succeeding five years.

A description of the plant now in use at the Barakar Iron Works has been given by McFarlane (**1120**).

Darjeeling.—Two occurrences of iron ore have been noted by Mallet (**1159**—6, 65):—

LOHARGARH (26° 48′ 30″: 88° 15′). A bed of impure hematite included in Tertiary sandstones, with a maximum thickness of about

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120 feet, and a length of outcrop of about a mile. The average yield of iron obtained from 3 samples was 30·6 per cent.

SIKBHAR (27° 1′ 30″ : 88° 35′). Bands of magnetite, associated with actinolite and micaceous hematite, exposed about a mile to E. S. E. of the village. The main ore band is about 20 feet thick, and consists when pure of a friable aggregate of magnetite crystals. These yielded on analysis 71·50 per cent. Fe, and the micaceous hematite 59·89 per cent. Fe. Neither contains phosphorus or sulphur. The deposit was worked to a small extent by Nepali smelters, who asserted that the magnetite produced iron of superior hardness and toughness, though more difficult to smelt than the micaceous ore.

BHUTAN.

Eden (**528**, 92) states that the soil in the neighbourhood of PARO (27° 23′ : 89° 29′ 30″) is highly charged with magnetic sand, which is used locally for manufacturing iron.

BIHAR AND ORISSA.

Bhagalpur.—According to reports quoted in the Agricultural Ledger (**104**), two kinds of iron ore are obtained in the district. (1), from the sands of hill streams; and (2), from lateritic gravels. The ore is finely powdered and sprinkled on a fire of charcoal, in a small clay built furnace. There were 21 furnaces at KATAURIA (24° 45′ : 86° 46′ 30″) in 1898, but the industry was declining.

Cuttack, *see* **Orissa** *below.*

Hazaribagh.—HAZARIBAGH (24° 0′ : 85° 25′). According to Williams (**1935**—2, 74), a lode of iron ore, 60 feet in breadth, is exposed among the crystalline rocks about a mile to the N. E. of the town, running in a nearly E. and W. direction. A portion of this band consists of the mineral named 'Calderite' by Piddington (**1405**—38). Ball, however, remarks (**71**—45, 375) that this and similar deposits of magnetite, reported as occurring in the district, are of no value as a source of iron.

KARANPURA (23° 50′ : 85° 15′). Two varieties of iron ore are mentioned by Hughes (**888**—7, 341) as occurring in the Karanpura coal field. The most abundant is the clay ironstone of the Ironstone shale group, of the same character as the ore occurring in that group in the Raniganj coal field. Beds of hematite, assaying from 50 to 60 per cent. of iron, also occur in the lower, or Barakar, group of the Damuda series. Both varieties were largely used by the *Agarias*, or native smelters. According to Thompson (**1771**—1, 3), there were

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23 furnaces at TENDWA, in the centre of the field, in 1854, each of which produced 160 lbs. of iron a day for six months in the year.

KARHARBARI (24° 10′ : 86° 20′). Smith, in a report to Government (**1655**—2, 97), states that a seam of iron ore 7 inches in thickness, lying at about 100 feet above the coal seams, is extensively worked by the native smelters. The yield is said to be about 32 per cent. of crude iron.

RAMGARH (23° 38′ : 85° 35′). The Ironstone shales are not well represented, according to Ball (**71**—2, 124), in the Ramgarh coal field, and the ore is of poor quality. The construction of the furnaces in use, and the methods of smelting and refining, have been described by Williams (**1935**—2, 57). About 60 furnaces were at work in 1852, each producing about 180 lbs. of refined iron a day.

Kalahandi.—No large masses of iron ore were observed by Walker (**1872**—3, 19). Concretionary limonite obtained from alluvial deposits is smelted by the native smiths. Near OLATURA (20° 20′ : 83° 36′) hematite occurring in bands alternating with garnetiferous quartzite is used locally to a small extent.

Manbhum.—The Ironstone shales of the Damuda series are but poorly represented in the Jharia coal field. Smith (**1655**—1), Hughes (**888**—1, 312), and Henwood (**825**—4) have all reported unfavourably on the quality of the ore, which is said to be so siliceous that the *Kumars*, or native smelters, could do little with it. Ferruginous concretions obtained from micaceous clay shales were used in a furnace at TELAIA (23° 49′ : 86° 14′).

According to Ball (**71**—46, 106), magnetic iron sand occurs in all parts of the district occupied by the crystalline rocks, and was formerly collected from the streams and smelted. The most considerable accumulation of magnetite occurs in a hill near TELUDI (23° 34′ : 86° 57′). Massive specimens of ilmenite, or titaniferous iron ore, were obtained at the foot of the hills to the W. N. W. of MANBAZAAR (23° 3′ 30″ : 86° 43′).

Ball has also described (*l. c.*, 77) the occurrence of lodes of hematite along the faulted junction between the metamorphic and submetamorphic (Dharwarian) rocks in the south of the district. The most important exposures of these ores were observed near KATRAH (22° 59′ : 86° 55′); to the N. and N. E. of AMBIKANAGAR (22° 57′ : 86° 49′ 30″); and further to the west in the hills near BAUCH (22° 59′ : 86° 40′). The ores are said to be rich and abundant (**B.** 373).

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Mayurbhanj.—The discovery of important deposits of iron ore in the Mayurbhanj State is due to Bose, who gave a brief description (**173**—20, 168) of their mode of occurrence in the year 1904. The deposits were subsequently examined, on behalf of Messrs. Tata and Sons, by Perin and Weld, from whose account of them (**1911**), and a summary of the same published in the Quinquennial Review of Mineral Production for 1909-13 (**862**, 108), the following particulars are taken.

The ores occur in the form of roughly lenticular bodies of hematite with small proportions of magnetite, in association with banded quartzites and quartz-iron-ore rocks, between intrusive masses of granite on the one hand and granulite or charnockite on the other. In all about a dozen ore bodies have been located, the most important of which are :—

(1) GURUMAISHINI (22° 18′ 30″ : 86° 21′). Three distinct and parallel leads, measuring respectively 7,000, 5,500 and 3,000 feet in length, and varying from 300 to 700 feet in breadth. There are also three large isolated masses, one of which forms the main peak of Gurumaishini hill, 3,000 feet above sea level. The total area is estimated at 19 millions of square feet, and the total quantity of ore proved at 15 millions of tons for every 10 feet in depth. Composition of ore (average of 10 samples) :—Fe=64·33 : P=0·075 : S=0·021 : SiO_2=1·64 per cent.

In addition there are large quantities of rubble or 'float' ore, which have been found to yield on analysis (average of 20 samples) : —Fe=61·46 : P=0·048 : S=0·036 : SiO_2=3·34 per cent.

(2) OKAMPAD (22° 9′ : 86° 17′). A single ore body, covering an area of 300,000 square feet, and at one point 300 feet thick. There are also two smaller outliers and about 165 acres of 'float' ore. Average analysis of 4 samples :—Fe=67·65 : P=0·043 : S=0·012 : SiO_2=1·58 per cent.

(3) BADAMPAHAR (22° 4′ : 86° 11′). A single lens measuring roughly 3,000 feet in length by 500 feet in breadth, with many small outliers. The outcrops of massive ore have been observed through a vertical height of 600 feet. No analyses of these ores have yet been published.

The ores of Gurumaishini hill are now being exploited by the Tata Iron and Steel Co., Ltd., whose works are situated at the junction of the Subarnarikha and Khorkai rivers near SAKCHI (22° 48′ 30″ : 86° 16′) in Singhbhum. These works have been designed for the production of 160,000 tons of pig iron and 100,000 tons of steel annually. Particulars of the progress of the undertaking and the equipment of the works have been published in the Quinquennial

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Reviews of Mineral Production (**861**, 107; **862**, 106), and in *Stahl und Eisen* (**35**—57); also by Perin (**1392**) and Sahlin (**1542**—1; —2).

The average quantity of ore raised annually in Mayurbhanj since the opening of the Tata Works has been 317,068 tons.

Orissa.—The iron industry of Cuttack and the Tributary Mahals of Orissa, though apparently never in a flourishing condition, was made the subject of special enquiries in the early days of the Geological Survey (*see* Oldham, **1326**—10, 11; Blanford, etc., **150**, 85).

The ores used by the native smelters were such as could be conveniently gathered on the surface, chiefly concretions of hematite weathered out from the sandstones of the upper Damudas, and to a less extent pisolitic nodules occurring in the lateritic deposits. The arenaceous hematites occurring in the Damuda beds of the Talcher coal field, though rich and apparently well adapted for smelting, were little worked.

The native processes of smelting and refining the iron were fully described by Oldham (*l. c.*, 14), who also discussed the prospects of introducing improved methods of manufacture. Accounts of these processes have also been given by Samuells (**1550**, 249) and H. F. Blanford (**147**—15).

Analyses of two specimens of the concretionary ores were published by Piddington (**1405**—74) in 1855. One of these, from KANKERAI (20° 58′ : 85° 3′ 30″) in Angul, contained 46·8 per cent. Fe; the other from PAL LAHARA (21° 26′ : 85° 15′), contained 47 per cent. Fe.

References to the iron industry and the distribution of iron ores in Orissa have also been made by Stirling (**1706**, 179), Kittoe (**994**—4, 144), and Righy (**1485**, 837)—(**B.** 361).

Palamau.—Ball (**71**—32, 65, 79, 112) has given a complete account of the iron ores of Palamau, and of the operations of the *Agarias*, or native smelters. Three varieties of ore are distinguished:—

(1) Magnetite, either pure or decomposed, occurring as veins in hornblendic rocks, or as disseminated crystals in granite. These were observed at several localities, but never in sufficient quantity to be of economic value.

(2) Clay iron ores and hematite, forming bands or strings of nodules in the shales, or concretionary masses in the sandstones of the Barakar group.

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(3) Red and brown hematite, forming bands in the laterite capping plateaus at a greater elevation than 3,000 feet. The most extensive development of these ores occurs on the plateau of NETURHAT (23° 29′ : 84° 19′). A sample from this locality contained 45·5 per cent. Fe.

The most important ores, as regards abundance and accessibility, are the claystones and hematites of the Barakar group. These are especially well developed in the Aurunga coal field, in the neighbourhood of RAJBAR (23° 47′ 30″ : 84° 41′), where they occur in a well defined zone of ferruginous shales, exposed for a length of 2 or 3 miles, and about 200 feet in thickness. They are still more abundant in an outlying patch of Barakars to the N. of BALUNAGAR (23° 50′ : 84° 43′ 30″), where they cover an area of about 4 square miles. In each case the ores are estimated to form about 10 per cent. of the whole bulk of strata in which they occur.

On analysis 5 samples yielded on the average 44·8 per cent. Fe.

Limestones eminently suited for use as flux are said to occur in abundance in the crystalline rocks near the western edge of the coal field. Proposals have been made (*see* Hewitt, **833**, 420) for the establishment of iron works on a large scale at BALUMATH (23° 50′ : 84° 51′), situated between the Aurunga and Karanpura coal fields.

The ironstone beds also occur in the Hutar coal field (*see* Ball, **71**—32, 97), in the neighbourhood of MORWAI (23° 46′ : 84° 9′) and NAWADIH (23° 50′ : 84° 5′), and have been used by the *Agarias*; but the quantity available is comparatively small. Three samples from this field gave an average of 49·4 per cent. Fe (**B.** 376).

Sambalpur.—The native processes of iron smelting as practised at AMDIAH, near Sambalpur, and KUTARBAGA (21° 39′ : 84° 11′), have been described by Rose (**1515**) and Babington (**56**). The ore was obtained, according to Ball (**71**—28, 182), from lodes of decomposed magnetite occurring among the crystalline rocks of the Kutarbaga range (**B.** 381).

Santhal Parganas.—In the Rajmahal hills, iron ores occur under the same conditions as in Birbhum (*see* Ball, **71**—26, 241). The highly ferruginous sandstones occurring beneath the Rajmahal trap are mainly used by the local smelters, according to Oldham (**1326**—6, 279).

Shahabad.—Sherwill (**1625**—5, 283) mentions the occurrence of iron ore in great abundance on the surface of the Kaimur table land, near its southern edge, in the neighbourhood of SURKI (?). Large heaps of iron slag were seen near SULYA (24° 48′ : 83° 39′).

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Singhbhum.—Ball (**71**—46, 146) gives a general account of the distribution of iron ores in the district. The most important occur in the form of lodes or veins in the sub-metamorphic or Dharwarian rocks, especially in the neighbourhood of, and to the W. of CHAIBASA (22° 33′ : 85° 52′). Some of the ore near LAGIA (22° 32′ : 85° 46′) is said to be rich in manganese. Three distinct veins were observed near JOGOHATU and CHINGIJARI, to the south of SAITBA (22° 33′ : 85° 39′ 30″), and they are said to be abundant near TENDU (22° 38′ : 85° 34″).

Since the year 1906, the Bengal Iron and Steel Co. have obtained supplies of ore for their works at Barakar from two deposits, situated at TURAMDIH (22° 43′ : 86° 15′) and HAKIGORA (22° 41′ : 86° 13′ 30″), to the S. of Kalimati, on the Bengal-Nagpur Railway. These were examined in 1908 by Fermor (*see* Holland, **859**—71, 41). The Turamdih ore forms patches or veins up to 3 feet in width in magnesian schists. At Hakigora the ores are banded magnetite and hematite quartzites. In both cases the chief supplies of ore have been obtained from the detrital deposits resulting from the disintegration of the rocks by weathering.

More recently, according to the Quinquennial Review of Mineral Production (**862**, 105), rich deposits of ore have been developed by the Bengal Iron and Steel Co. at PANSIRA or NOTU HILL (22° 19′ : 85° 26′) and BUDA HILL (22° 17′ : 85° 20′ 30″), S. E. of Manharpur on the Bengal-Nagpur Railway. The total quantity of ore available has been estimated at 10 million tons; and average samples have given the following results on analysis:—Fe=64·00 : P=0·05 : Mn =0·06 : SiO_2=3·00 per cent.

The quantity of iron ore raised in Singhbhum increased from 8,825 tons in 1906 to 151,662 tons in 1914. In 1915 there was a slight falling off, to 127,040 tons.

Talcher *see* **Orissa** *above.*

BOMBAY.

Although the ores of iron, especially those of a lateritic origin, are widely distributed in the Bombay Presidency, practically no use is now made of them. In the districts of Ahmedabad, Kaira, the Panch Mahals, and Surat, large mounds of iron slag afford the only evidence of the former existence of the industry, and no information is available regarding the quality or relative abundance of the ores employed (**B.** 398).

During the five years ending with 1914, the quantity of iron ore returned as having been raised in the whole of the Presidency has not exceeded one ton annually.

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Bijapur.—Occurrences of iron ore in the Kaladgi series were noted by Foote (**596**—12, 258, 263) at three localities :—

AMINGARH (16° 3′ 30″ : 76° 1′). The breccias near the base of the Kaladgi series are locally rich in hematite. The form of furnace in use is illustrated on page 264.

BASSARGI (15° 54′ : 75° 14′). Rich brown hematite forming the matrix of a breccia of chert.

BISNAL (16° 23′ 30″ : 75° 33′). Four beds of richly hematitic schist interstratified with quartzite, occurring about 1½ mile to S. by E. of the village.

In all cases the ore was being smelted on a small scale at villages in the neighbourhood of the outcrops.

Cutch.—A description of the process of iron manufacture in Cutch was given by Grant (**691**—3, 293) in 1837, when the principal works were situated in the neighbourhood of DUDHAI (23° 19′ : 70° 11′). The ore, according to Wynne (**1975**—11, 87), was derived either from beds of hematitic laterite in the sub-Nummulitic group, or from highly ferruginous deposits associated with stratified trap near BUCHAO (23° 18′ : 70° 24′). In 1872, when Wynne wrote, the industry had become extinct (**B.** 401).

Kathiawar.—A detailed report on the iron industry of Kathiawar was drawn up by Jacob (**924**—1) in 1840. At that time iron was being smelted at RANAWAO (21° 41′ : 69° 48′) and RANPUR (21° 50′ : 69° 44′). From the description of the furnace, it appears to have been of a different type from that commonly used in other parts of India. Outwardly it bore some resemblance to a reverberatory furnace, being oblong in shape and built of brickwork lined with clay, with a chimney at one end and apertures for the blast and the removal of the slag on opposite sides at the other end. The ore, however, was not kept entirely separate from the fuel, but was laid on a bed of charcoal in the body of the furnace, and covered with a layer of the same. About 2 cwts. of ore were smelted at a time, and the yield is said to have been about 40 per cent. The yearly output of each furnace was about 16 tons.

The ore was obtained from lateritic deposits in the neighbourhood of BAKHARLA (21° 44′ : 69° 41′ 30″), at a depth of from 5 to 20 feet below the surface. Fedden (**569**—6, 133) also states that ore was formerly obtained from ironstone bands near the top of the Umia (Jurassic) group, and was smelted at KANTRORI (22° 46′ : 71° 24′), where there are very large mounds of iron slag (**B.** 400).

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Adye (**11**, 208) mentions the occurrence of lateritic deposits of iron ore at the following localities in the Navanagar State :—

Ridge and surrounding low ground 1½ mile to S. of SAMBELIA BET (22° 18′ : 69° 24′).

Northern slope of a ridge, 2 miles to W. S. W. of HABARDI (22° 13′ 30″ : 69° 26′).

The S. W. end of a ridge at MAHA DEVIA (22° 12′ : 69° 20′).

TAMBA TALAO, 1½ mile to E. S. E. of NANDANA (22° 8′ : 69° 21′).

KHOKHRA DHAR, a ridge on the outskirts of LAMBA (21° 54′ : 69° 22′ 30″).

Hillock, 2 miles to S. E. by E. of BHATIA (22° 6′ : 69° 20′).

CHEQUE DHAR, about 2 miles to E. of WADWALA (21° 50′ : 70° 0′ 30″).

Some highly ferruginous dykes were observed about 3⅓ miles to S. S. E. of JAM JODHPUR (21° 54′ : 70° 5′ 30″).

Ratnagiri.—The mode of occurrence of iron ores in the southern Konkan was described in 1842 by Gibson (**654**—2), and in 1856 by Aytoun (**51**—3, 79), the latter of whom advocated the establishment of an iron foundry at SAVANTVADI (15° 55′ : 73° 52′). Lateritic ores, which are widely distributed, were commonly used for smelting; but veins of magnetite and hematite are also mentioned as occurring in crystalline rocks at MALVAN (16° 3′ 30″ : 73° 31′), which was then the chief centre of manufacture. A specimen of micaceous hematite from this locality analysed by Royle (**1529**—3), is said to have contained 69 per cent. Fe.

A description of the native methods of dressing and smelting the ore has been given by Shastree (**1614**); and Foote (**596**—12, 267) gives an illustration of the peculiar bottle-shaped furnace in use in the State of Savantvadi (**B.** 398).

The iron ores occurring in the crystalline (Dharwarian) rocks of this neighbourhood have recently attracted attention with a view to their exploitation for export to Europe (*see* Hayden, **793**—28, 18). The most promising occurrences have been located in Goa; at REDI (15° 45′ : 73° 43′) in Ratnagiri; and near BANDA (15° 48′ 30″ : 73° 55′) in Savantvadi.

Rewa Kantha.—In 1852 Fulljames (**629**—9, 112) gave a description of the iron ores found in the western portion of this and the adjoining districts, but does not mention either the quantity available or the quality of the ore. Large quantities of iron slag occur in several places, especially in the neighbourhood of JAMBUGHODA

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(22° 22′ : 73° 48′) and NARUKOT (22° 23′ : 73° 45′ 30″), where the ore was probably derived from Dharwarian rocks (**B.** 399).

In **Rajpipla** iron was formerly worked over an area of about 16 square miles in the Jhagadia and Valia Taluks, according to Bose (**173**—23, 182). Large mounds of slag were seen at several localities. At LIMODRA (21° 44′ : 73° 12′ 30″) they are said to cover an area of about 6 acres, to an average depth of 5 feet. The ore was obtained from lateritic deposits. An average sample from DUNGRI (21° 32′ : 72° 11′) gave 73·17 per cent. oxide of iron, 10·68 per cent. of silica, and 9·26 per cent. of alumina.

A sample of hematite from the hills N. of MORIARI (? MUDHIARI or MUTHYARI, 22° 25′ 30″ : 73° 48′ 30″) in **Chota Udaipur,** analysed at the Imperial Institute (**514**—5), contained Fe=56·9 : P=0·074 : SiO_2=16·68 per cent.

Satara.—Iron ore in the form of nodular hematite, associated with laterite, is mentioned by Sykes (**1736**—1, 426) as being worked at MAHABLESHWAR (17° 56′ : 73° 43′). He remarks that this was the only metallic ore met with in the Deccan (**B.** 398).

Sind.—Vicary (**1845**—5, 341) mentions the occurrence of iron ore at the base of the hills to the N. N. W. of KOTRI (25° 22′ : 68° 22′). According to Blanford (**148**—63, 193), the ore occurs in bands, often from 15 to 20 feet thick, in the passage beds between the Khirthar and Ranikot groups, especially in the neighbourhood of LAINYAN (25° 40′ : 68° 12′ 30″), and to the E. of BANDH VERA (25° 34′ : 68° 8′). Portions of the bands only are said to be sufficiently ferruginous to deserve the name of ore. Some ferruginous rock also occurs at the base of the Manchar group near Bandh Vera, but is of doubtful economic value (**B.** 402).

BURMA.

An average annual production of 14,400 tons of iron ore is recorded in Burma during the five years 1910 to 1914, and in 1915 of 15,526 tons, but the districts whence the ore was obtained are not stated in the published returns. A large proportion of the output is due to the operations of the Burma Corporation at Bawdwin, where the ore is used as a flux in treating the refractory lead slags left by the Chinese miners.

Amherst.—According to the description given by Helfer (**808**—1, 9; —7, 181) and O'Riley (**1340**—3, 734), the iron ores of the district are all of a lateritic character. They are said to cover

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extensive areas in the valleys of the Salween and its tributaries, and to be especially abundant on the GYAING R. (16° 38′ : 98° 1′). Hematite containing 85 per cent. of metal is said to occur at several places on the ATARAN R. (16° 8′ : 98° 2′) and its tributary the ZIMME.

Kyaukpyu.—Walters (**1880**—4, 264) states that iron of excellent quality was formerly smelted from lateritic ores on the island of Ramri. Iron ore is not mentioned among the mineral resources of the island by Mallet (**1159**—14).

Mandalay.—Some apparently rich deposits of iron ore have been noted by Datta (**424**—3, 121) as occurring in the neighbourhood of SINGAUNG (ZEGÔN, 21° 58′ : 96° 27′) and TWINNGÉ (21° 57′ 30″ : 96° 25′) on the Shan plateau. The extent and depth of the deposits could not be determined.

The deposits at Twinngé are now being worked by the Burma Corporation, Ltd., in order to supply flux for the treatment of the lead ores at the Bawdwin mines. They have recently (1916) been examined by Coggin Brown (*Records, G. S. I.*, XLVII, 137), who found that the ore occurs in rounded grains, pebbles, and masses sometimes several feet in diameter, forming a layer near the base of the mantle of red clay which overlies the dolomitic limestone of the Shan plateau. The ore is considered to be of a residual character, representing the ferruginous matter originally disseminated through that portion of the limestone which has been removed by denudation. The ore bed has an average thickness of about 3 ft., and the quantity originally available was estimated at about 275,000 tons. The proportion of iron contained in average samples ranges from 56·3 to 60·1 per cent.

The Devonian shales exposed at WETWIN (22° 6′ : 96° 38′ 30″) are highly ferruginous in places along the outcrop, but trial pits have shown that the ore is merely superficial.

Mergui.—Helfer (**808**—6, 180) states that considerable quantities of iron ore occur on MAOIN or MEAING I. (12° 22′ : 98° 30′), 10 miles to the S. W. of Mergui. The ore was pronounced by Ure (**1827**—2, 237) to be of good quality, with a specific gravity of 3·18 to 3·37. Similar ores were observed on KALA-KHUING I., near the mouth of the Lenya R.; on two islands to the W. of MALCOLM'S I.; and on WHITE PIGEON I. to the N. of the mouth of the PAKCHAN R. (10° 0′ : 98° 35′). The ore is said to contain from 40 to 60 per cent. Fe (**B.** 415).

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Lateritic iron ores are widely distributed, according to Bose (**173**—18, 161), in the valley of the Great Tenasserim R., but appear to be of inferior quality. An exceptionally pure sample from THERABWIN (12° 18′ : 99° 3′) contained 50·49 per cent. Fe.

Myingyan.—A large proportion of the iron produced in Upper Burma under native rule is said to have been smelted in the neighbourhood of the extinct volcano of POPA or PUPPA (20° 55′ : 95° 18′). According to Blanford (**148**—6, 219; —8), the furnaces were of the most primitive kind, being merely holes dug in a bank of clay, and no artificial blast was employed. The ore was collected, in the form of concretions of brown hematite, from Pliocene gravels surrounding the base of the mountain (**B.** 416).

Myitkyina.—Bleeck (**151**—3, 262) mentions the occurrence of 'bog iron ore', outwardly resembling laterite, forming broad horizontal terraces in the valley of the URU (UYU) R. to the W. of HWEKA (25° 29′ : 96° 20′). A sample on analysis gave:—Fe= 77·54 : SiO_2=1·63 : Al_2O_3=7·37 : H_2O=13·46 per cent., with traces of phosphorus.

Prome.—The upper portion of the 'Fossil-wood' or Irrawaddy group of eastern Prome and the adjoining districts of Upper Burma is characterised, according to Theobald (**1763**—6, 83; —16, 253) by a profusion of concretionary nodules of brown hematite. These nodules were extensively smelted when the country was under Burmese rule, but the industry has long been extinct (**B.** 414).

Shan States (S.).—Large masses of brown hematite were observed by La Touche (**1031**—45, 374) along the outcrop of the Naungkangyi (Ordovician) shales on the eastern side of the LOI TWANG RANGE (21° 56′ : 97° 43′) in the State of Kehsi Mansam. The shales themselves are not particularly ferruginous, and the occurrence is probably an instance of superficial enrichment of the weathered portion of the beds.

Tavoy.—Helfer (**808**—2; —5, 28), Low (**1097**—2, 147), and O'Riley (**1340**—3, 735) all mention the occurrence of iron ore in large quantities near the town of TAVOY (14° 4′ : 98° 14′). There are said to be two beds of ore, one of which forms a hill 2,000 feet in length, 400 feet broad, and 40 feet in height.

Two samples of the ore were analysed by Ure (**1827**—2), who reported that they contained 60·55 per cent. and 60·2 per cent. of iron respectively, with traces of phosphate of lime (**B.** 415).

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Toungoo.—According to Theobald (**1763**—19, 91), thick beds of lateritic iron ore, consisting of a mixture of the protoxide and peroxide, occur along the base of the hills to the E. of the Sittang R. These deposits were described by Fryar (**625**—6), who states that they are specially abundant between YONDAING (18° 0′ : 96° 54′) and THANZEIK (18° 4′ : 96° 53′).

CENTRAL INDIA AGENCY.

Bijawar.—A general description of the mode of occurrence of iron ore in Bundelkhand has been given by Medlicott (**1197**—2, 44, 81). Two varieties of ore are worked. The more important is a massive red hematite occurring in bands of clay at the top of the Bijawar series. The other is of lateritic origin, and is said to be of inferior quality, and not sufficiently abundant to be worked on a large scale (**B.** 393).

Dhar (Nimanpur).—Bose (**173**—5, 66) mentions two localities where iron ore has been worked :—

N. E. of BHAURIKHERA (22° 22′ 30″ : 76° 27′). The ore is said to be very rich, occurring close to a fault line between the Vindhyans and Bijawars.

S. E. of JHIRPANIA (22° 29′ 30″ : 76° 23′ 30″). Surface deposits in the Bijawars.

Gwalior.—BAGH (22° 22′ : 74° 51′). Extensive quarries of iron ore are mentioned by Oldham (**1326**—18, 119) as having been formerly worked in this neighbourhood. The ore is a light yellow hematite, occurring, according to Blackwell (**139,** 4), as a vein from 10 to 15 feet in thickness in sandstones. The yield is said to be about 35 per cent. Fe.

PAR HILL (26° 2′ 30″ : 78° 6′). Iron ore was formerly worked on a somewhat extensive scale at this and other localities in the neighbourhood. The mode of occurrence has been described by Hacket (**730**—1, 41). The ore consists of hematite, occurring as thin laminæ in variegated clays resulting from the decomposition of jaspideous shales, forming the lower portion of the Morar group, or upper member of the Gwalior series. Layers of hematite occur throughout the whole formation, the thickness of which amounts to about 2,000 feet; but it is only in places where the silica has been dissolved away that the ore is workable. Mines were also worked at MANGOR (26° 5′ 30″ : 78° 6′ 30″) and SANTOW (26° 6′ : 78° 11′ 30″), and to a smaller extent at intermediate places. In all cases the ore occurs under the same conditions as at Par hill.

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A series of samples from various localities, analysed by Schwarz, gave an average yield of 66 per cent. Fe. (**B.** 394).

Indore.—Bose (**173**—5, 65, 67) mentions occurrences of iron ore at the following localities:—

BARWAI (22° 15′ : 76° 6′). The ore occurs in Bijawar breccia, in a band 10 to 12 feet thick. Picked samples yielded 35 per cent. Fe. An abortive attempt was made about the year 1860 to establish iron works here under the superintendence of a Swedish metallurgist, Mr. Mitander; but when the works had been erected and a large quantity of ore had been provided, the enterprise was abandoned by Government. The ore was obtained from the following localities in the neighbourhood:—CHIKTIMODRI (22° 17′ : 76° 10′ 30″), KARONDIA (22° 19′ : 76° 7′), MENDIKHAIRA (22° 22′ : 76° 14′), and NANDNIA (22° 16′ 30″ : 76° 4′)—(**B.** 397).

(**Nimawar**).—Between BAIN (22° 25′ : 76° 45′ 30″) and SENDRANI (22° 28′ : 76° 40′ 30″). The ores in this area are said to be abundant and rich. They were specially examined in 1907 by Sethu Rama Rau (*see* Holland, **859**—66, 50). The original rock appears to have been a hematitic shale, at the base of the Vindhyans, but ore also occurs lining fissures and hollows in the underlying Bijawars, and in the form of nodules and lumps in the disintegrated surface rock.

Jhabua.—Iron ore deposits reported to occur at PIPLADE (22° 46′ : 74° 42′), and on the SANAR R. (22° 48′ : 74° 42′), were found on investigation (*see* Holland, **859**—66, 48) to be too small and of too low a quality to admit of successful working.

Panna.—Both lateritic ores and the ferruginous breccia associated with the Bijawar strata occur, as in the adjoining State of Bijawar (*see* Vredenburg, **1854**—18, 313). Franklin (**616**—1, 277) alludes to the abundance of the former in the valley of the KEN R., but remarks that they were not largely worked.

Rewah.—Iron was formerly manufactured on a large scale from hematite obtained from the transition (Bijawar) rocks of the Son valley (*see* Oldham, **1325**, 172), but the industry has greatly declined. The smelting of iron at KHAIRAHI (24° 5′ : 82° 47′ 30″) in Singrauli is mentioned by Roberts (**1492**, 483) and Smith (**1655**—2, 94). The ore here was derived from coal measure (Damuda) rocks, but is

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said to have been of poor quality, not more than 17·5 per cent. of iron being extracted by the smelters.

CENTRAL PROVINCES.

Statistics of the iron industry in the Central Provinces, compiled from reports by the district officials, are given for the year 1898 in the *Agricultural Ledger*, Volume V, No. 17, and for the years 1904 to 1913 in the Quinquennial Reviews of Mineral Production (**861**, 117; **862**, 119). The following extracts from these figures, giving the number of furnaces at work in the years specified, will illustrate the general trend of the industry:—

District.	1898.	1904.	1909.	1913.
Balaghat	..	8	4	..
Bhandara	14	..	..	..
Bilaspur	..	..	103	99
Chanda	23	41	9	20
Damoh	1	..	..	..
Drug	..	..	56	40
Jubbulpore	25	98	26	29
Mandla	51	46	65	49
Narsinghpur	25	8	4	..
Raipur	33	68	230	181
Saugor	35	18	13	19
TOTAL	207	287	510	437

The quantity of iron ore raised in the Provinces during 1898 amounted to 3,027 tons, as against 2,387 tons in the preceding year. During the quinquennial periods 1904 to 1908, and 1909 to 1913, the average annual production remained at about the same level, being 2,189 tons and 2,611 tons respectively; but in 1914 the output showed a sudden increase to 18,402 tons, the cause of which is not stated in the returns, but is probably connected with prospecting

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operations in the Jubbulpore district. In 1915 the output fell again to 4,747 tons.

Bastar.—Bose has recorded the existence of rich and extensive deposits of iron ore in the Antagar tahsil (*see* Griesbach, **708**—31, 38). Two localities are specially mentioned :—

HURTELI (19° 56′ 30″ : 81° 7′ 30″). The ore is due to the lateritisation of bands of hematite-quartzite.

TOPAL (20° 8′ 30″ : 81° 13′). The ore appears to be the product of decomposition of a dense dioritic rock.

Chanda.—ASOLA (20° 13′ : 79° 53′). Datta (**424**—5) reports a lode of hematite lying about a mile to N. W. of the village, traceable at the surface for about 400 yards, and with an average thickness of 30 to 40 feet. Analysis :—Fe=65·99 : SiO_2=3·89 per cent. This lode is referred to by Hislop (**843**, 380) and Hughes (**888**—20, 110) as the Gunjwahi deposit.

BISSI (20° 38′ : 79° 28′). Hughes (**888**—12, 78) records a lode, containing hematite and magnetic oxide of iron, about a mile directly E. of the village.

CHAMOURSI (19° 56′ 30″ : 79° 57′). Iron ore was observed by Datta (*see* Hayden, **793**—24, 71) in the quartz hills to the S. E. The quantity available is unknown.

DEWALGAON (20° 23′ : 80° 3′). Hislop in 1855 (**843**, 380) called attention to the abundance of iron ore at this locality. Khandeshwar hill, a crag 250 feet in height, to the S. E. of the village, is said to consist almost entirely of ore, but Datta (**424**—5, 310) found that the bulk of the rock is only slightly ferruginous.

Two lodes of hematite were discovered by Datta (*l. c.*) close to the village :—

(1) 100 yards to N. W. Exposed portion of lode 255 feet long, 4 feet 6 inches to 9 feet 6 inches thick. Analysis :—Fe=61·2 : SiO_2=11·04 per cent.

(2) 400 yards to S. by E. Visible portion of lode 300 yards long, average width 20 feet. Analysis :—Fe=67·76 : SiO_2=1·50 per cent.

LOHARA (20° 24′ : 79° 47′ 30″). As described by Hughes (**888**—12), the iron ore forms a hill three eighths of a mile in length, 200 yards in breadth, and 120 feet in height. The lode has been traced by Datta (**424**—5) southwards for a distance of about 2½ miles, appearing to die out about a mile to the S. of ALIWAHI (20° 22′ 30″ : 79° 45′), and consists of hematite-quartz-rock, occasion-

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ally so siliceous as to be valueless as an ore. The amount available is said to be very large. Analysis by Forbes (**597**) :—Fe=69·208 : P=0·005 : S=0·012 : SiO_2=0·823 per cent.

PIPALGAON (20° 32′ 30″ : 79° 33′). An excessively fine mass of red hematite, resembling the ore at Lohara, is recorded by Hughes (**888**—12, 78) as occurring at about three quarters of a mile to the E. of the village. Analysis by Ness (**1288**—3) :—Fe=71·05 : SiO_2= 4·5 per cent., with traces of phosphorus and sulphur.

POSER (19° 56′ : 80° 12′). A band of hematite was traced by Datta (*see* Hayden **793**—24, 71) for a distance of 275 yards, with an average thickness of about 20 feet. The ore contains 69·8 per cent. Fe.

RATNAPUR (20° 21′ : 79° 37′ 30″). Hughes records (**888**—12, 78) a very rich lode of brown iron ore, in places 40 or 50 feet wide. Analysis by Ness (**1288**—3) :—Fe=49·7 : insoluble matter=26·0 per cent.

WINGNUR (19° 46′ 30″ : 80° 15′ 30″). Lodes of iron ore were observed by Datta (*see* Hayden, **793**—24, 71) in the range extending from this locality to EMAGARH (19° 42′ : 80° 32′). The amount available is not known.

YEMLAPALI (19° 7′ : 79° 54′). According to King (**987**—23, 197), brown and red hematite occur in abundance in the sandstones of the Chikiala group, in the valley of the Pranhita R. It is smelted to a limited extent at many places along the edge of the outcrop, especially at Yemlapali on the Pranhita. The furnace in use and process of smelting are described.

In the year 1875, Ness (**1288**—3; —4) described the results of practical experiments made at Warora in smelting iron ore from Lohara and Ratnapur with Warora coal. Two trials were made, lasting for 4 and 5 days respectively, but in neither of them was the iron reduced to a liquid condition; though it is stated that the heat developed was sufficient to melt the fire-brick lining of the hearth (*see also* Hughes, **888**—20, 141). The results of these experiments were afterwards discussed by Hackney (**731**), who agreed with Ness that the failure was due to the soft and impure character of the coal employed (**B.** 387).

Finally, Schwarz (**1594**—2) reported on the ores of Lohara and Pipalgaon, with a view to the establishment of iron works on a large scale in the neighbourhood. It was proposed to use charcoal as fuel, and it was thought that, with proper conservation of the forests, an output of 25,000 tons of iron per annum might be provided for in the first instance. DURGAPUR, on the Erai R., was suggested as a suitable site for the erection of the works.

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Drug.—In the year 1887, Bose (**173**—7) gave an account of the iron ores in the western portion of the Raipur district, since included in the district of Drug. The principal deposits were found in the following areas :—

DAUNDI-LOHARA ZEMINDARI.

DHALLI RAJHARA (20° 34′ : 81° 6′). These are the most important deposits in the district, consisting of bands of hematite developed in thin-bedded Chilpi (Dharwarian) sandstones, and extending for a total distance of about 20 miles. They have recently been examined by Weld (**1911**) on behalf of the Tata Iron and Steel Co. The purer ores occur in the form of lenticular masses or bodies at two horizons; those in the lower band being from 2,000 to 3,000 feet in length and 100 feet or so in thickness; while those in the upper band are comparatively small. The largest mass, forming the crest of Rajhara hill, was proved by boring, and estimated to contain 10 million tons of ore. Average results of analyses,—Surface samples :—Fe=66·35 : P=0·058 : S=0·108 : SiO_2 = 1·44 : Mn=0·151 per cent. Core samples :—Fe=68·56 : P=0·064 : S= 0·071 : SiO_2=0·71 : Mn=0·175 per cent.

GANDAI ZEMINDARI.

MAGARKUND (?). Iron is smelted from nodules of hematite derived from ferruginous Chilpi sandstone.

KAIRAGARH FEUDATORY STATE.

In the hilly western portion of the State there is an abundance of iron ore, both lateritic, and hematite occurring in Chilpi sandstone. The ores are worked at BORLA (21° 21′ 30″ : 80° 50′ 30″), KATULKASSA (21° 20′ : 80° 48′ 30″), etc.

NANDGAON FEUDATORY STATE.

Lateritic ore occurs over an area of 8 square miles in the neighbourhood of JURLAKHAR (21° 30′ : 80° 48′).

THAKURTOLA ZEMINDARI.

At CHUTRALA (21° 34′ 30″ : 80° 56′) iron ore occurs under the same conditions as at Magarkund in Gandai. Lateritic ores are worked at KUMI (21° 35′ : 80° 52′) and BASANTAPUR.

WORARBAND.

Iron ore occurs in lateritic deposits to the W. of WORAR (21° 4′ : 80° 53′ 30″), but has not been utilised.

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Hoshangabad *see* **Nimar** *below.*

Jubbulpore.—The iron ores of Jubbulpore are confined to the north-eastern portion of the district, where they are developed in connection with a belt of Bijawar (Dharwarian) rocks surveyed in 1871 by Hacket (*see* Oldham, **1326**—71, 9), who gave the name of 'Lora group' to the principal iron-bearing strata. The ores were subsequently classified by Mallet (**1159**—36) as (1), Bijawar ores, consisting mainly of micaceous, siliceous, and manganiferous hematite with some limonite; and (2), Lateritic ores, consisting mainly of pisolitic limonite, with a smaller proportion of hematite. To these Fermor (**577**—33, 259) has added a third, or Lateritoid, group, formed by secondary replacement along the outcrop of the Dharwar rocks. The Dharwar ores are chiefly developed in the pargana of Khumbi, to the E. and S. E. of SIHORA (23° 29′ : 80° 10′), and the lateritic ores in the pargana of Bijeragogarh, in the neighbourhood of KATNI (23° 50′ : 80° 28′)—(**B.** 384).

The following are the principal localities mentioned :—

AGARIA (23° 23′ : 80° 13′). The ores consist of soft micaceous hematite and harder, schistose hematite, with a thin capping of laterite, exposed in a hill half a mile to the S. of the village. The total quantity of ore available was estimated by Mallet (**1159**—36, 97) at about 14 million tons; but this estimate has been enormously reduced by Martin and Louis (**1179**), who reported that the ore forming the bulk of the hill is not suitable for blast furnaces, and that the laterite capping might supply about 750,000 tons of ore, containing 45·67 to 58·58 per cent. of iron. Analyses of the ores gave the following average result,—Lateritic ores (3 samples) :—Fe=53·37 : P=0·146 : S=0·02 : SiO_2=9·78 per cent. Hematite schists (2 samples) :—Fe=59·55 : P=0·078 : S=0·02 : SiO_2=7·92 per cent.

A band of hematite schist, 4 to 5 feet thick, forming the crest of a ridge running westwards from Agaria hill, was also examined by Martin and Louis. Analysis :—Fe=50·07 : P=0·074 : S=0·036 : SiO_2=11·37 per cent.

BIJORI (23° 48′ : 80° 34′). Several sections of the laterite at this locality and in the neighbourhood are given by Mallet (**1159**—36, 104). The ore, pisolitic limonite, occurs in thin inconstant bands at a depth of 2 to 3 feet below the surface. The average aggregate thickness of ore, measured in 8 pits, was 3 feet 9 inches. Two samples yielded on analysis 56·84 and 50·20 per cent. of iron respectively, with 1·29 and 7·94 per cent. of insoluble matter.

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Dharampur-Gosalpur (23° 24′ : 80° 7′). Bose (**173**—9, 73) has given details of a number of trench sections at these localities, showing numerous bands of micaceous and manganiferous hematite. The total apparent thickness of ore amounts in places to 50 feet, according to Mallet (**1159**—36, 102), but the ores are of a lateritoid character, and do not continue in depth. A sample from Gosalpur yielded 57·10 per cent. Fe, and 1·69 per cent. P_2O_5.

Ghogra (23° 29′ : 80° 15′). The ore here is a micaceous, manganiferous and siliceous hematite, containing 46·43 per cent. Fe, 12·26 per cent. Mn, and 9·35 per cent. of insoluble matter. It is said to produce a steely iron, used in making edged tools (Mallet, **1159**—36, 101).

Imalia (23° 46′ 30″ : 80° 26′). Pisolitic limonite, of the same description as the Bijori ore, is quarried here and at other localities between this place and Katni (Mallet, **1159**—36, 107). Two samples contained 54·47 and 52·66 per cent. Fe respectively.

Jauli (23° 23′ 30″ : 80° 17′ 30″). Mallet (**1159**—36, 99) describes the ore as a semi-ochreous hematite interbanded with quartzose layers, with a total thickness of about 150 feet. A large amount of the ore has been quarried for use as paint. Martin and Louis (**1179**) did not consider the deposit workable as a source of ore under modern conditions. Four picked samples gave the following average result on analysis :—Fe=60·01 : P=0·096 : S=0·030 : SiO_2 10·11 per cent.

Kanhwara Hills (23° 55′ 30″ : 80° 30′). Lateritic ores,—pisolitic limonite,—occur over an area of at least $2\frac{1}{2}$ square miles, according to Mallet (**1159**—36, 108). There are three bands of ore from 2 feet to 2 feet 6 inches thick, and the total quantity available is estimated at 49 million tons. A sample from the uppermost seam yielded 57·52 per cent. Fe, and 0·76 per cent. P_2O_5.

Lora Hill (23° 30′ : 80° 13′). Mallet (**1159**—36, 100) describes this range of hills as consisting mainly of ferruginous siliceous schist, composed of alternating layers of micaceous hematite and quartz. The greater proportion of the rock is too siliceous to be of value as ore.

Saroli (23° 24′ : 80° 15′ 30″). Two low hillocks to the S. of the village are composed, the one wholly, the other partly of schistose and micaceous hematite. Mallet (**1159**—36, 98) estimated the total quantity of ore available at $3\frac{1}{2}$ million tons; but as the ore is believed to occur on the same horizon as that at Agaria, it is probably equally unsuited for modern requirements. Two samples yielded 64·55 and 68·02 per cent. Fe respectively.

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SILONDI (23° 30′ : 80° 10′). Martin and Louis (**1179**) noted two bands of siliceous hematite, 40 feet and 20 feet thick respectively, at this place, which is close to Sihora railway station. Samples yielded from 44·95 to 52·15 per cent. Fe. The deposits were considered to be valueless under present conditions.

The native methods of smelting have been described by Bose, (**173**—9, 87), Holes (**858**;—1;—2), and Wynne (**1977**). Fernandez (**579**) has given an account of experiments in iron smelting with a native furnace carried out during the rains, and with the addition of a flux. The feasibility of carrying on the operations throughout the year was demonstrated, but it is said that the use of a flux did not increase the output of iron.

MURWARA, near Katni, was recommended by Mallet (**1159**—36, 115) as a site for the establishment of iron works.

Narsinghpur.—OMARPANI or TENDUKHERA (23° 10′ 30″ : 78° 56′). The excellent quality of the iron manufactured at this locality attracted a considerable amount of attention between the years 1855 and 1857, when the mode of occurrence of the ore, and the native methods of smelting were described by Jacob (**923**—2, 47), Winscom (*see* Balfour, **69**—2, 207), Medlicott (**1199**—1, 24), and Blackwell (**139**). At that time 70 or 80 furnaces were at work at Tendukhera, with an output of about 140 tons annually; but Bartlett (**81**) states that in 1898 the number had declined to 7, and according to the latest returns the industry has completely died out.

The ore was mined at Omarpani, 2 miles from Tendukhera, and consists, according to Medlicott, of hard, earthy, red and brown hematite, with occasional masses of specular ore, irregularly distributed in fissures and hollows among Bijawar limestones and quartzites. No estimate of the quantity available has been made. Medlicott attributes the superior quality of the iron produced to the fact that the ore is slightly calcareous. The yield is said to have been about 40 per cent.

Steel was produced, according to an unpublished report by Franklin, by reheating and hammering the crude metal eight times. After the third operation, the heated metal was rolled in burnt cowdung before being hammered, and finally, when red hot, was plunged into water (**B.** 385).

Nimar.—The occurrences of iron ore in the northern portion of the Nimar and Hoshangabad districts, along the valley of the Narbada R., have been described by Jacob (**923**—1; —2), Medlicott (**1199**—1, 24), Blackwell (**139**), and Oldham (quoted by Medlicott,

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1199—3, 271). The ores worked were almost invariably hematite, obtained from breccias occurring in the Bijawar series near their junction with the Vindhyans, or from surface accumulations of debris formed by the disintegration of the same rocks. Bose (**173**—5, 64) has given a list of the principal localities where the ores were worked :—

BASNIA, 3 miles E. of the Chota Tawa R. A superficial deposit.

BILLORA (22° 14′ : 76° 8′ 30″). Ore occurs in metamorphic schists, 1½ mile to E. of village. It is too poor in quality to be worked with profit.

CHANDGARH (22° 15′ 30″ : 76° 40′ 30″). Apparently a surface deposit, close to the base of the Vindhyan sandstones. Jacob gives the yield as 63·4 per cent. Fe.

KAJBERI (22° 22′ : 76° 59′). In Bijawar breccia, close to the boundary line with the metamorphic rocks.

Between KHUDIA (22° 14′ : 76° 47′) and MOHLA (22° 16′ : 76° 46′). In Bijawar Breccia.

KOTRA, near BIJALPUR (22° 12′ 30″ : 76° 41′). A vein *in situ* at the junction of the Bijawars with Vindhyan sandstones.

MATNI (22° 16′ : 76° 37′). The ore is said to be very rich, occurring in Bijawar breccia.

NANDANA (22° 21′ : 76° 43′). In Bijawar breccia. The ore is said to be poor.

NIMKHERA or LEMEKHAIRA (22° 18′ : 76° 58′). Ore similar to that of Barwai in Indore; said to occur in large quantities.

SONTALAI (22° 21′ : 76° 56′). Nicholls (**1299**) has described an occurrence of iron ore, formerly worked, about 2½ miles W. of the village. The deposit was apparently of limited extent.

Raigarh.—In the Rampur (Raigarh-Hingir) coal field, Ball (**71**—21, 107, 120) noted the occurrence of zones of ironstone at two horizons in the Barakar group. These ores are most abundant in the neighbourhood of KODALOI (21° 47′ 30″ : 83° 53′), and were largely used by the native smelters. The quality is said to be good, but no analyses were made (**B.** 381).

Saugor.—HIRAPUR (24° 22′ : 79° 16′). The process of iron smelting at this locality has been described by Oldfield (**1322**). The ore was obtained from lateritic deposits associated with Bijawar rocks, and is said to be abundant.

Yeotmal (Wun).—YANAK HILL (19° 51′ 30″ : 79° 8′). In 1870 Oldham (**1326**—62) published analyses of specimens of iron ore from the

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Wun area, showing an average proportion of 56 per cent. Fe. He refers also to the existence of bands of conglomerate in the Vindhyan rocks of Yanak hill, containing pebbles of hematite yielding 68·5 per cent. Fe. Hughes (**888**—20, 111), however, considered these bands to be of little value as a source of ore.

HYDERABAD.

Bilgrami (**126**) has given a sketch of the geology of the Nizam's dominions, followed by a general description of the iron ore resources and of the native process of manufacture. The ore commonly used is magnetite, occurring in granules disseminated through granitoid gneiss, schist, or sandstone, and is either separated by winnowing from the disintegrated rock, or collected from the sands of rivers. It contains on the average about 66 per cent. Fe. Lateritic iron ore also occurs in large quantities, but is only used to a limited extent. The richest varieties contain about 46 per cent. Fe.

Bidar.—Iron was formerly smelted on a small scale from nodules of hematite occurring in lateritic deposits, which cover a wide area to the S. of KALIANI (17° 53′ : 77° 0′). Furnaces were seen at work by Newbold (**1294**—32, 998) at MARBI and BOCHIRI, on the road to Gulbarga. The ore was crushed and roasted before being smelted. The output of each furnace was about 64lb. of iron a day.

Nizamabad.—KONASAMUDRAM (18° 44′ : 78° 35′) is said to have been one of the localities where the steel used in the manufacture of the famous Damascus sword blades was made. The process has been described by Voysey (**1853**—5), who witnessed it in operation in 1820, when the place was still visited by Persian traders for the purpose of purchasing the steel. Two kinds of iron were used,—one smelted from magnetic sand obtained at MIRTAPALLI (?) ; the other from lateritic ore brought from KONDAPUR (18° 30′ : 78° 30′). These were smelted together in crucibles, in the proportion of 3 to 2, with fragments of glass slag. The mixture was subjected to a very high temperature for 24 hours, after which the cakes of steel, each weighing about 1½lb., were covered with clay and annealed in the furnace for 15 or 16 hours, the process being repeated if necessary. Steel was also manufactured in a similar manner at DIMDURTI (? DEMATHOORTY, 19° 5′ : 78° 38′) from magnetite granules disseminated through gneiss and hornblende schist. According to Malcolmson (**1158**—7, 106 ; —8, 546), the ore was obtained by pulverising and

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washing the rock, the harder portions being previously roasted (**B.** 358).

Raichur.—Newbold (**1294**—23, 932) has noted the existence of a band of hematite, formerly smelted by the Hindus, in the Jiaddigudd hills to the S. E. of TAWURUGIRI (15° 46′ : 76° 28′). Foote (**596**—12, 51) also alludes to the presence of beds of very rich hematite schist in these hills. The industry had died out owing to the lack of fuel.

Warangal.—Walker (**1868**—1, 390 ; —3, 725; —4, 222, —5; 182) has described the iron resources of the eastern districts of Hyderabad. The ores used were mainly derived from lateritic deposits, especially where these rested on trap. Extensive smelting is said to have been carried on in the parganas of Kollur and Anantagiri (**B.** 359).

PEDDA GOPATTI (17° 10′ 30″ : 80° 19′). The occurrence of beds of fairly rich magnetic iron ore, associated with hornblendic schist, was noted by Foote (**596**—28, 17). The ferruginous beds form two low ridges, extending for a considerable distance to the southward. The ore does not appear to have been mined.

SINGARENI (17° 31′ : 80° 19′ 30″). In the same paper (**596**—28, 19) Foote calls attention to the existence of a large and important bed of magnetic iron ore near the southern boundary of the Singareni coal field. The outcrop of the ore was traced for a distance of about 3 miles, forming a ridge estimated at 150 to 300 feet in height. The ore is said to be very rich in quality.

KASHMIR.

Iron ore was formerly worked on a somewhat extensive scale between the villages of SOAP or SOF (33° 37′ : 75° 21′ 30″) and KOTHAIR (33° 40′ : 75° 19′), where its mode of occurrence has been described by Vigne (**1846**—4, Vol. I, 337) and Verchère (**1839**—2, 186). In 1888, when the locality was visited by La Touche (**1034**—14, 68), the industry was almost extinct. The ore is an impure calcareous limonite, occurring in layers from a few inches to 2 feet in thickness among shales and limestones of upper Triassic age. The workings consist of burrows, barely large enough to admit the passage of a man extended at full length, driven along the dip at frequent intervals to a depth of 30 or 40 yards.

Jammu.—Iron ore has been extensively mined, according to Medlicott (**1197**—41, 54), from a band of siliceous breccia occurring

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at the top of the 'Great Limestone' series in the SANGAR MARG coal field (33° 12′ : 74° 41′). The ore is a cellular limonite, forming the matrix of the breccia, and has probably been derived by infiltration from the overlying nummulitic beds.

MADRAS.

In 1858 Balfour (**69**—2) compiled a detailed report on the iron resources of the Madras Presidency, from which the following particulars of the state of the industry in the various districts are abstracted :—

Arcot (N.), p. 13. Accounts by Heyne (**834**—2, 189), Bourdillon, and Brooke are quoted. Magnetic sand collected in the streams is chiefly used. Ironstone is mined at SANNAMALAI HILL, in the Arni Taluk, and in POLUR. About 200 furnaces were in operation. The outturn of each was about 7 cwt. annually.

Arcot (S.), p. 35. The ores are found in small patches close to the surface. A list of villages where iron is smelted is given.

Bellary, p. 40. Iron sand and lateritic ores are both used. The yield of malleable iron is about 33 per cent. A list of ore localities and furnaces is appended, and the operation of smelting is described. The annual production of iron is said to be about 570 tons.

Chingleput, p. 63. Magnetic iron ore is said to exist in great abundance, but smelting is not actively carried on.

Coimbatore, p. 65. Magnetic sand is used. Malleable iron and a variety approaching steel in hardness are produced, the latter specially at PALGHAT (10° 45′ : 76° 43′).

Cuddapah, p. 67. Iron sand, said to yield about 50 per cent. Fe, is smelted at RAMIAPULLEM(?). Lateritic ores, yielding about 33 per cent. Fe, are used in other localities.

Ganjam, p. 75. A poor variety of lateritic ore, yielding only 14 per cent. Fe, is smelted at GUMSUR (19° 50′ 30″ : 84° 41′).

Godavari, p. 191. Accounts by Heyne (**834**—2, 218, 224) are quoted. The ore is obtained from a bed of lateritic gravel, not more than 18 inches in thickness, immediately beneath the surface. The industry had become extinct.

Guntur, p. 77. Lateritic ore is quarried in the Datchapalli, Timerkota, and Narasaraopet Taluks. Twenty-seven furnaces were at work, with an annual outturn of about 2 tons. A description of the furnace and process of smelting is given.

Kistna, p. 124. Lateritic ores exist in some quantity, but are not largely used. The yield is about 25 per cent. of crude iron.

Kurnool, p. 101. Lateritic ores are said to occur in extreme abundance throughout the district.

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Madura, p. 117. A report by Muzzy (**1278**, 101) is quoted. Iron sand and lateritic ores are widely diffused. A list of villages and of furnaces in each is given.

Malabar, p. 102. Accounts by Buchanan-Hamilton (**222**—1, Vol. II, 437) and Conolly are quoted. Lateritic ores, yielding about 25 per cent. of crude iron, are used.

Nellore, p. 182. Lateritic ores are used, but are not widely distributed. Iron is smelted at 14 villages in the Udayagiri Taluk. The annual output is about 56 tons.

Nilgiri, p. 175. Observations made by Benza (**110**—3, 249) are quoted. Thick beds of magnetite, interstratified with quartz, are said to occur near KOTAGIRI (11° 24′ 30″ : 76° 56′), and large masses of hematite in the valley of the MOYAR R.

Salem, p. 197. The account is compiled from various sources (*see* Leschenault de la Tour, **1062**—1, 344 ; Prinsep, **1436**—11 ; Heath, **799**—3 ; Campbell, **272**—8 ; and Newbold, **1294**—45, 763), and describes the processes of iron smelting and of manufacturing *wootz* or **steel.** The ores used are hematite and magnetic iron sand obtained from the river beds. A list of the villages where iron ore is mined and smelted is given.

South Kanara, p. 60. Lateritic ore, broken into small pieces, is used. The furnace is merely a cavity in the ground. The yield is about 33 per cent. Fe. The island of BASWARAJ DRUG (14° 19′ : 74° 27′ 30″) is mentioned as the principal locality.

Tinnevelly, p. 216. Magnetic iron sand collected from the streams at the foot of the hills is used. About 70 furnaces were at work, with an annual outturn of about 230 tons.

Travancore, p. 224. Lateritic ore and iron sand are both used. At SHENKOTTA (? 8° 12′ : 77° 26′) about 130 tons of crude iron were produced annually. In an experiment with ore from UDAGIRI (8° 14′ 30″ : 77° 24′) the yield was about 45 per cent. of good iron.

Vizagapatam, p. 229. Iron is manufactured to a limited extent in the hill tracts from lateritic ores, and a fine quality of **steel** is made. The yield varies from 17 to 25 per cent. of metal.

The following papers also deal generally with the iron industry of southern India :—

1843. Campbell (**272**—16). Discusses the possibility of establishing iron works on a large scale.

1857. Sowerby (**1679**—5). Gives a list of the iron ores of the Presidency, with remarks on their qualities.

1892. Holland (**859**—11). Describes the nature and distribution of the iron ores in the southern districts of the Presidency ; discusses the question of fuel supply ;

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and describes the native processes of iron and steel manufacture.

The following particulars are derived from reports published since the compilation of Balfour's work, and dealing with special areas :—

Arcot (N.) Holland (**859**—11, 7) mentions the occurrence of beds of magnetic iron ore to the S. of GUDYATAM (12° 57′ : 78° 56′), and 2½ miles to the W. of VELLORE railway station (12° 55′ : 79° 11′ 30″).

Arcot (S.) Particulars of a large number of exposures of magnetite in the eastern and northern portion of the Kalrayanmalai are given by King and Foote (**988**, 291). The most important beds were observed in the neighbourhood of SANKARAPARAM (11° 53′ : 78° 58′ 30″), CHINNA TIRUPADI (11° 43′ : 78° 51′ 30″), and MADUR HILL (11° 45′ : 78° 46′ 30″).

In 1830 iron works on a considerable scale were established at PORTO NOVO (11° 30′ : 79° 49′) by Mr. J. M. Heath, and were subsequently carried on by the Porto Novo Steel and Iron Co. and the East Indian Iron Co. The latter Company also erected a blast furnace at TIRUVANNAMALAI (12° 14′ : 79° 8′). Although a large portion of the iron produced was exported to England, to be used in the manufacture of steel, the enterprise never met with financial success, and was finally abandoned in 1867. Detailed accounts of the operations of the Companies have been published by Garstin (**636**, 441) and Maylor (**1194**—2)—(**B.** 349).

Bellary.—Foote (**596**—34, 25 ; —39, Chap. V) has described the occurrence of numerous bands of siliceous hematite in the SANDUR HILLS, to the west of BELLARY (15° 9′ : 76° 59′), and on the MALLAPAN GUDDA (14° 55′ : 76° 2′). The richest mass of ore was observed half a mile to the S. of KAMMAKARAVU (15° 1′ : 76° 40′ 30″), forming the crest of a ridge 150 ft. in height ; but the softer varieties of ore were preferred by the native smelters at KANNEVIHALLI (15° 3′ : 76° 34′).

Chingleput.—A bed of magnetic iron ore, about 3ft. thick, is mentioned by Holland (**859**—11, 7) as occurring about a mile to the S. of the Sub-Collector's bungalow at CHINGLEPUT (12° 42′ : 80° 2′).

Coimbatore.—Thomas (**1766**) gives a list of the localities where iron sand, which is the ore commonly used, is collected. According to Holland (**859**—11, 7), magnetite of good quality is said to occur in the Kollegal Taluk, and a very rich bed in the Doddancombai forest, in the Satyamangalam Taluk.

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Cuddapah.—According to notes by C. Æ. Oldham, quoted by King (**987**—7, 280), bands of arenaceous hematite occurring in the Cuddapah series are worked in the neighbourhood of YERAGUNTLAKOTA (13° 58′ : 79° 20′) and CHINTAKUNTA (13° 44′ : 79° 14′). The ore is brought from the eastern slopes of the hills between these places, and is said to be tolerably rich, yielding from 25 to 33 per cent. of crude iron. An account of the iron industry in the district is also given by Gribble (**707**—1, 26).

Godavari.—Blanford (**148**—30, 114) mentions the existence of large quantities of magnetic iron ore, occurring in laminæ with quartz, in the metamorphic rocks to the S. of POLAVARAM (17° 15′ : 81° 42′). The ore was smelted on a very small scale.

Kistna.—Concretions of clay ironstone occur in abundance, according to King (**987**—18, 255), in the sandstones of the Golapilli, Tripati, and Rajamahendri groups, to the W. of Rajamahendri. Iron was smelted in the neighbourhood of RAMAKAPETA (16° 53′ 30″ : 80° 56′), KOMERA (16° 58′ : 81° 20′ 30″), and PENTLAM (16° 53′ : 81° 30′ 30″). The process employed is fully described, and an elaborate account by Heyne (**834**—2, 218), who witnessed the operation at the village of LATCHMIPURAM (17° 1′ 30″ : 81° 22′), is quoted (**B.** 358).

Kurnool.—Iron ore, in the form of layers, veins, and nests of hematite, is freely distributed among the rocks of the Cuddapah and Kurnool series, according to King (**987**—7, 277), but has only been worked in the former series. The finest occurrence was observed in the GUNIGAL ridge (15° 34′ : 78° 5′), where the ore is chiefly developed along a number of east-west faults, and is associated with quartzites. Bands of highly ferruginous quartzites have also been worked along the western slopes of the Nalamalai range between NANDIALAMPET (14° 43′ : 78° 51′ 30″) in Cuddapah and NANDIAL (15° 29′ : 78° 32′). Smelting was carried on at ROODRAR (RUDRAVARAM, 15° 14′ : 78° 40′), and other villages in the neighbourhood. The process of iron making in this tract has been fully described by Wall (**1875**—6). The daily outturn of each furnace is said to be about 48lb. of refined iron (**B.** 356).

Malabar.—The gneissose rocks of the Ernad and Walluvanad Taluks in south Malabar are occasionally ferruginous. The following localities are mentioned by Lake (**1025**—1, 237) and Holland (**859**—11, 8):—

Hematite-gneiss, 1½ mile to the S. W. of NILAMBUR (11° 17′ : 76° 17′).

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Garnetiferous rock with bands of hematite, 6 miles to E.S.E. of WANDUR (11° 12′ : 76° 18′) ; and friable ore 9 miles to E. of the same place.

Bands of ferruginous gneiss, a mile to the S. of PORUR (11° 9′ 30″ : 76° 19′).

Hematite gneiss, 2 miles to the S. E. of YEDDAKURICHI (10° 57′ : 76° 34′ 30″).

Crystallised magnetite in gneiss was mined near NEMINI (11° 3′ : 76° 16′).

The furnace in use and process of smelting are fully described by Buchanan-Hamilton (**222**—1, Vol. II, 437) and Holland (**359**—11, 16). An account of the process, and of the manufacture of **steel**, was also given in the *Colliery Guardian* (**35**—54) in 1874.

Iron works were established by the Porto Novo Steel and Iron Co. in 1833 at BEYPUR (11° 10′ : 75° 52′), the ore being obtained from FERUK, near Beypur, and from VERKELLA HILL near CALICUT (11° 15′ : 75° 50′). Its occurrence at the latter locality was described in 1819 by Babington (**55**, 329), who says that it contains 75 per cent. Fe. The works were closed in 1867 (**B.** 350).

Analyses of samples of the Malabar ores made at the Imperial Institute (*see* Dunstan, **514**—7, 18) gave the following results :— Walluvanad ore, Fe=37·63 : S=0·010 per cent. Wandur ores (average of 3 samples), Fe=49·56 : S=0·019 per cent. One sample contained 0·14 per cent. P_2O_5.

Nellore.—Two important groups of magnetic iron ore have been described by Foote (**596**—17, 17) :—

(1) ONGOLE group. Four or five bands of ore are exposed in the KONIJEDU HILLS (15° 26′ : 80° 2′ 30″); at ONGOLE (15° 30′ : 80 °6′ 30″) ; and in PARNAMETTA HILL (15° 32′ : 80° 4′). These are probably connected with each other beneath the alluvial deposits. The two upper bands are said to be the richest.

(2) GUNDLAKAMMA group. Ores are exposed at the following localities :—

BURAPALLE (15° 41′ : 80° 2′ 30″). Two thick beds, separated by granitoid gneiss, form part of a considerable hill.

MANIKESAVARAM (15° 45′ 30″ : 80° 1′). A bed, exposed for about a mile, forms a small hill W. of the village.

SINGARIKONDA (15° 52′ : 80° 2′). Five beds, of which three are moderately rich in parts only, form the main ridge of two hills.

VEMPARALA (15° 54′ : 80° 0′). Four rather unimportant beds.

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A smaller bed, not connected with these groups, is exposed on the left bank of the MANERU R., 3 miles to the S.W. of SINGARA KONDA (15° 14′ : 80° 5′ 30″). The bed is exposed for about three quarters of a mile, and is said to be moderately rich.

Several beds of hematite schist were noted in the Chundi hills, to the W. of POLENANE CHERUVU (15° 12′ : 79° 42′ 30″). Only one or two of the beds are said to be rich in quality.

In the southern portion of the district, King (**987**—17, 142) has described the occurrence of numerous bands of quartzose hematite in the valley of the SWARNAMUKHI R., between TRESALMARE (13° 51′ 30″ : 79° 56′) and IRCOLA (13° 48′ 30″ : 80° 0′). The beds are said to be thick, consisting of laminæ of quartz and grey iron ore weathering into red and brown hematite.

In the Nellore Manual (**174**, 63), Boswell gives a list of the localities at which iron ore was mined and smelted (**B.** 358).

Nilgiri.—Fairly rich beds of magnetite and hematite occur among the gneissose rocks of the Nilgiri hills. The most important beds were observed by Blanford (**117**—3, 219, 248) near KARACHOLA, a mile and a half to the W. of KOTAGIRI (11° 24′ 30″ : 76° 56′), and on a spur of DODABETTA (11° 23′ : 76° 48′) overlooking the Dhobi's village. Pure strings of hematite, interfoliated with gneiss, were noted at JACKATALLA (WELLINGTON, 11° 21′ 30″ : 76° 51′). Congreve (**348**—2, 242, 249) also remarks upon the varieties of iron ore occurring at Ootacamund.

Pudukotai.—Foote (**596**—18, 147) mentions the occurrence of a bed of magnetic iron ore in gneiss about a mile to the N.E. of MALLAMPATTI (10° 36′ 30″ : 78° 43′ 30″). In another report (**596**—24, 98) he remarks that iron was formerly smelted on a considerable scale from lateritic ore at AYANGUDI (10° 21′ 30″ : 79° 2′ 30″).

Salem.—Iron ores occur in great abundance in this district, and are in fact considered by Holland (**859**—11, 9) to be practically inexhaustible. Five principal groups of magnetic iron ore beds have been distinguished by King and Foote (**988**, 279 *seq.*) :—

(1) GODAMALAI (11° 41′ : 78° 25′), p. 280. There are two main parallel beds of ore, traced from the western end of the Godamalai through VALUR, NAIAMALAI, and MANUR to the neighbourhood of MONDAKULI (12° 6′ : 78° 41′) on the Ponniar R., a total distance of about 35 miles. On the Godamalai itself the main bed has an average thickness of between 50 and 100 feet, and forms precipices several hundred feet in height. The ore is interlaminated with

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quartz, the former occurring in the proportion of three-fifths to five-sixths of the mass.

The petrology of the Godamalai beds has been studied by Holland (**859**—30, 111), who shows that both hematite and magnetite are present in the ores.

(2) THALAIMALAI-KOLIMALAI, p. 284. Two series of beds are exposed at intervals, forming a great curve with its apex to the S.W. of KIRAMBUR (11° 12′ : 78° 9′). On the southern branch of the curve the iron beds appear at a little to the N. of TATTAIYANGARPETTAI (11° 7′ : 78° 30′), and extend westwards along the northern flanks of the THALAIMALAI (11° 4′ 30″ : 78° 23′) to the S. of Kirambur. On the north-eastern branch they appear at VELLALAPATTI (11° 20′ : 78° 11′), and are lost sight of on the northern spurs of the KOLIMALAI. The inner series of beds is not well developed on the southern branch of the curve, but to the N.E. it contains important beds of ore on the E. and N. flanks of KANAVAIPATTI HILL (11° 11′ : 78° 12′ 30″) ; on the NAINAMALAI spur (11° 19′ : 78° 16′) ; and on the ridge above PAILAM (11° 22′ 30″ : 78° 24′). Further to the N. E. some magnetic ore beds exposed at TAMMAMPATTI (11° 26′ 30″ : 78° 33′) may belong to this series.

(3) SINGAPATTI or SINGAPURAM (11° 37′ 30″ : 78° 28′), p. 288. Three principal beds of ore are exposed on either side of a synclinal fold, whose axis runs from W. to E. N. E. The greatest visible development is on the northern side of the fold. The beds appear to die out in the direction of ETTAPUR (11° 40′ : 78° 32′ 30″) on the Vellar R., but are believed to extend to the N.E. into the Kalrayanmalai, in South Arcot.

(4) THIRTAMALAI (12° 5′ : 78° 40′), p. 289. Two great beds of ore form the crest of the range, and are probably continued northwards beyond the Ponniar R. The iron smelted from these beds is said to be held in great estimation. A bed of ore exposed in a ravine to the S. of TALTUKI (11° 57′ : 78° 35′) may belong to this group.

(5) KANJAMALAI (11° 37′ : 78° 7′). The ores of this group are the most valuable in the district, and are described in an Appendix to the report (p. 379). Their distribution and geological relations have also been described by Holland (**859**—5, 141). The rocks composing the hill are disposed in the form of an elliptical, synclinal basin, greatly disturbed to the N. W. by intrusive dykes of granite, basic, and ultrabasic rocks. At least five beds of ore have been noted, of which the two lowest are the most important. These measure 50 and nearly 100 feet in thickness respectively, and their outcrops form conspicuous terraces surrounding the hill. The total quantity of ore available is considered to be practically inexhaustible.

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About the year 1853 a blast furnace was erected by the East Indian Iron Co. at PALAMPATTI (11° 39′ : 77° 49′ 30″) on the Cauvery, in order to work the Kanjamalai ores. The operations have been described by Sowerby (**1679**—6, 49). The capacity of the furnace was 5 tons a day, and the average yield of metal about 60 per cent. In 1903, however, a trial made in London with an average sample of the ore, and coal from the Sanctoria seam in Bengal, gave a yield of 39 per cent. only (*see* Dunstan, **514**—7, 19), and the ore was pronounced to be unsuitable for blast furnace purposes.

In addition to these groups of beds isolated exposures have been observed at the following localities :—

ATTUR (11° 35′ 30″ : 78° 40′). At the southern foot of Attur hill.

MALLIKARAI (11° 34′ : 78° 33′). A small but rich bed.

NAMAGIRIPETTA (11° 27′ : 78° 20′). A small bed at the southern base of the Kheddamalai, to the N. of the village.

PAITHURMALAI (11° 32′ 30″ : 78° 37′). Two good beds of ore.

Analyses of 16 samples from various localities in the district, made at the Imperial Institute (*see* Dunstan, **514**—7, 12), show that in all cases the ores consist of a mixture in various proportions of magnetite and hematite. The average results showed :—Fe=55·07 : S=0·028 per cent. Two samples from the Kanjamalai contained 0·30 and 0·62 per cent. of phosphoric acid respectively.

The native form of furnace in use, and the process of smelting, have been fully described by King and Foote (**988**, 374) and by Holland (**859**—11, 17). With regard to the manufacture of **steel**, Holland (**859**—5, 146 ; —11, 20) has shown that the process adopted by the natives of Salem is essentially different from that involved in the making of *wootz* or crucible steel, as practised in Trichinopoly and other districts of Southern India. The Salem process consists in the de-carburisation of globules of cast iron, which are melted off in the ordinary process of smelting wrought iron. The globules are pounded in a mortar in order to remove adhering slag, and are then smelted with charcoal in a small pit dug in the ground. De-carburisation is complete in about half an hour.

Holland (**859**—5, 149) has also discussed the question of fuel supply in the Salem district, and has shown that, with efficient management of the reserved forest areas, sufficient timber would be available for the manufacture of about 1,500 tons of iron annually.

Travancore.—Foote (**596**—25, 34) noticed abundant traces of the former existence of an iron smelting industry in the neighbourhood of Cape Comorin. The ore used was probably magnetic sand.

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According to the reports of the State Geologists (**298**, 20, 34, 48) no deposits of iron ore of commercial value have yet been discovered.

Turner (**1819**—1) has given an account of the process of manufacturing **steel** at UDAGIRI (8° 14′ 30″ : 77° 24′). The iron, prepared in the ordinary way, is said to have been smelted in crucibles with bone ashes, and annealed 15 or 16 times.

Trichinopoly.—Blanford (**147**—8, 216) mentions that ferruginous concretions collected from the Utatur and Ariyalur (Cretaceous) groups were formerly smelted, but the industry is now extinct (**B.** 347).

Several beds of magnetic iron ore are mentioned by King and Foote (**988**, 295) as occurring in the south-eastern portion of the PACHAIMALAI. These are :—

(1) A large and generally rich bed stretching along the southern margin of the hills, and disappearing near the saddle connecting YESANAI HILL (11° 17′ 30″ : 78° 51′) with the main range.

(2) A bed of poor ore along the ridge of YELAMBALUR HILL (11° 16′ : 78° 56′).

(3) A large and generally rich bed, extending from SANDAPURAM HILL(?) across the KILA KANAVAI pass (11° 12′ : 78° 52′) to the northern spur of SATTARAMANI HILL (11° 10′ : 78° 51′).

The manufacture of *wootz*, or crucible **steel**, by the carburisation of wrought iron, as practised in the Trichinopoly district, has been fully described by Heath (**799**—3), Hunter (**894**—18, 149), and Holland (**859**—11, 21). The iron is placed in crucibles, made of a ferruginous clay and charred rice husk, with wood of the *Avaram* tree (*Cassia auriculata*) and leaves of *Calotropis gigantea* or *Convolvulus laurifolius*, and sealed with clay. The crucibles are arranged in the furnace in batches of 25, forming a flat arch, and are subjected to a continuous blast for about 2 hours. The steel is produced in the form of small conical ingots, each weighing from 8 to 11 ounces (**B.** 352).

The composition and properties of *wootz* are discussed in the following papers :—

1795. Pearson (**1377**). Ascribes its properties to the presence of a small proportion of iron oxide, dissolved in the mass.

1805. Mushet (**1277**). Considers that its properties are due to imperfect reduction, and a larger proportion of carbon than in cast steel.

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1818. Stodart (**1708**). Points out the suitability of *wootz* for the manufacture of surgical instruments.
1819. Faraday (**565**). States that specimens contain traces of silica and alumina.
1820. Stodart and Faraday (**1709**). Describe attempts to imitate *wootz* by fusing an alloy of iron and alumina with good steel.
1852. Henry (**821**). States that no trace of alumina could be detected in the specimens analysed.
1870. Rammelsburg (**1455**—1). Gives analyses of *wootz*, and discusses its composition.
1885. L. D'A. J. (**916**). Gives a brief history of the *wootz* industry.

Vizagapatam.—Walker (**1872**—2, 175) states that iron is smelted at a large number of places in the country occupied by the crystalline schists. Magnetite-quartz schist was found near MODPOLOR (18° 46′ 30″ : 82° 23′); concretionary limonite near MALSAMA (19° 1′ : 82° 18′); and compact limonite near BAGCHUA (19° 2′ 30″ : 82° 28′ 30″). The limonites are probably merely superficial formations, from which no great quantity could be obtained.

A lode of rich brown hematite, forming the matrix of a breccia filling a fissure in the Kurnool (?) series at CHITRA (19° 4′ : 82° 30′), is mentioned by Ball (**71**—45, 360). The ore has been mined for a distance of about a mile.

Several localities in the neighbourhood of NARAINAPATAM (18° 52′ 30″ : 83° 14′), at which iron ore was formerly mined, are mentioned by Vertue (**1843**, 271).

An account of the iron industry in 1869 has been given by Carmichael (**285**, 154). **Steel** of excellent quality is said to be made at MADGUL (18° 2′ : 82° 37′).

MYSORE.

The earliest accounts of the iron industry in Mysore were given by Buchanan-Hamilton (**222**—1, Vol. I, 170) and Heyne (**834**—2, 44, 358), both of whom described the operations of iron and steel making in the Bangalore and Chitaldroog districts. The steel (*see also* C. V. B., **52**) was prepared in crucibles, in the same manner as in Trichinopoly. The ore used was apparently a mixture of magnetic iron sand and lateritic ore. Newbold (**1294**—44, 649 refers to the abundance of iron sand in the hilly tract near SEVERNDRUG (SAVANDURGA, 12° 55′ : 77° 21′), and mentions several villages in the neighbourhood where smelting was carried on. Clark (**321**—

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2, 120) mentions the occurrence of magnetic and hematitic ores in the BABA BUDIN HILLS, in the Kadur district (**B.** 352).

The iron resources of the province have recently been investigated by the State Geological Department, and a classification of the ores, drawn up by Smeeth, is quoted in the Quinquennial Review of Mineral Productions for 1909—1913 (**862**, 115). The observations are summarised below :—

Chitaldroog, Shimoga, and Tumkur.—Two papers by Sambasiva Iyer (**1548**—5; —7, 243) contain particulars of the iron industry in these districts. The ores are mainly derived from two parallel ranges of hills, extending from the neighbourhood of HULIYAR (13° 35′ : 76° 36′) to the N. N. W. for a distance of over 30 miles. They consist of brown hematite, yielding from 25 to 59 per cent. of iron, with traces only of sulphur and phosphorus, and 2 to 3 per cent. of silica. They are worked in open quarries. The output of the native furnaces at CHIK BAYALKERE (13° 42′ : 76° 35′) and DODKITTADAHALLI (13° 56′ 30″ : 76° 26′) is about 7 tons annually. **Steel** is manufactured in crucibles at GATTIHOSHALLI (13° 59′ 30″ : 76° 21′) near Talya, in the Chitaldroog district.

Kadur.—BABA BUDIN HILLS. Sampat Iyengar (**1549**—6, 74) and Slater (**1649**—9, 54) have described the occurrence of massive bands of magnetite and hematite-quartzite in these hills. The bands are said to be sometimes more than 500 ft. in thickness, and average samples yielded 42 per cent. Fe. Two minor bands lying to the E. of ATTIGUNDI (13° 25′ 30″ : 75° 48′) were found to contain 64·54 per cent. Fe. These were traced for a distance of a mile and a half, with an average width of 18 ft.

The iron ores of this region have also been fully described by Smeeth (**1652**—17, 58), particularly those occurring in an area 9 or 10 sq. miles in extent, in the neighbourhood of VIRUPAKSHIKAN HILL (13° 30′ 30″ : 75° 46′ 30″). The quantity available, over an area of 3 sq. miles, was estimated at about 25 million tons within 3 or 4 ft. from the surface, containing between 60 and 65 per cent. of iron ; and in addition about 60 million tons lying at about 6 to 7 ft. from the surface, containing from 55 or 58 per cent. of metal. The amount of phosphorus ranges from 0·044 to 0·105 per cent., and sulphur occurs only in small quantities.

UBRANI (13° 51′ : 75° 58′ 30″). Slater (**1649**—5, 23) has noted the occurrence of strong bands of magnetic and chrome iron ore in diorite among the hills to the W. of Chilanhalli and Ubrani. These ores have not been worked, but the iron furnaces at Ubrani are

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supplied from beds of lateritic hematite found about 3½ miles to the S.S.W. of the village. Extensive deposits of similar ore were observed at a mile to the N.N.E. of SHIDDARHALLI (13° 48′ 30″ : 75° 52′), and to the N.E. of GANGUR (13° 51′ : 75° 53′ 30″).

Mysore.—MALVALLI area. Several outcrops of magnetic iron ore in this neighbourhood have been described by Evans (**555**—1). The principal exposures are :—

(1) Spur at S. end of hill 6 miles to the S.E. of MADDUR (12° 35′ 30″ : 77° 7′). Ore of good quality, about half a mile in length.

(2) Hill 1 mile to the N.E. of TIPPUR (12° 30′ 30″ : 77° 11′). Ore of good quality.

(3) About ¾ mile to the N.E. of HUSUGUR (12° 27′ : 77° 12′). A line of low hills, containing ore of good quality, formerly smelted at Husugur.

(4) Hills to the S.E. of HULLAHALLI (12° 25′ 30″ : 77° 12′ 30″). Important beds of ore.

(5) Hills E. of the SHUMSHA R. Outcrops extend from a point half a mile to the S. of KARALKATTI (12° 23′ : 77° 17′) to the Malvalli-Kankanhalli road near HULALGUR (12° 25′ 30″ : 77° 17′). The ore is highly magnetic and of excellent quality.

(6) Outcrops running from a point S. of CHETANHALLI (12° 21°′ : 77° 10′ 30″) in a S.S.E. direction to the left bank of the Cauvery R. The beds in places are of great thickness.

(7) Half a mile to the W. of GANGANA CHUKKI (12° 18′ : 77° 13′ 30″). A vein of pure hematite at least half a mile in length, and about a foot in average thickness.

Slater (**1649**—8) and Smeeth (**1652**—17, 55) state that the ores in this area consist of magnetite-bearing charnockites and granulites, and would require to be crushed and concentrated before smelting. Experiments showed that 2 tons of ore would yield about a ton of concentrates containing about 65 per cent. Fe. According to Smeeth, there would be no difficulty in obtaining a million tons of ore.

SARGUR (12° 0′ : 76° 27′ 30″). Outcrops of iron ore were observed by Jayaram (**937**—7, 80), strongly developed in the charnockite series near the village.

Shimoga.—A list of localities where iron was formerly smelted is given by Slater (**1649**—7, 51). The ores used were derived from magnetite-quartzites and from beds of hematite.

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Tumkur.—Primrose (**1431**—8, 210) has given a description of the process of smelting, which is performed in large clay crucibles. The ore used is iron sand.

NEPAL.

Hodgson (**849**—3, 641) mentions an iron mine at GORLI KHARAK(?) in the valley of the Arun Kosi R. The output is said to be very large.

NORTH-WEST FRONTIER PROVINCE.

Bannu.—Iron ore is said to occur in abundance among the hills to the S.E. of BANNU (33° 0′ : 70° 40′). The metal is worked up at Kalabagh into nails, cooking utensils, etc. (Baden-Powell, **60**—1, Vol. I, 8). The ore appears to be an earthy hematite (**B.** 404).

Bajaur.—Raverty (**1463**—2, 332) and Oliver (**1332**—1, 5) mention the occurrence of iron ores in large quantities in the valley of the Panjkora R., especially in BARAUL and in the LASPUR and JANDAWAL HILLS. The iron is exported to Kabul, where it is said to be greatly esteemed. The ore is believed to be magnetic iron sand (**B.** 404).

Hazara.—A band of earthy, concretionary or pisolitic hematite, associated with felsitic breccia, was observed by Middlemiss (**1219**—17, 26, 286) on the N.E. spur of SIRBAN HILL (34° 7′ : 73° 16′). In places the band consists of good earthy hematite, 5 to 6 ft. in thickness, which would be useful as an ore if fuel were available.

Waziristan.—KANIGURAM (32° 31′ : 69° 51′). The manufacture of iron at this locality has been described by Agha Abbas (**15**, 588) and Verchère (**1839**—2, 20). The latter observer states that the ore is a highly ferruginous shale occurring beneath nummulitic limestone, and that apparently limestone is used as a flux, though the actual operation of smelting was not witnessed. Specimens of the ore collected by Stewart (*see* Oldham, **1326**—24) proved to be calcareous limonite, containing from 31·8 to 40·4 per cent. of metal (**B.** 403).

TOCHI VALLEY. Smith (**1657**—1) noted the occurrence of concretions of very pure soft hematite in middle or lower Eocene sandstone beds at MIRAN SHAH (32° 58′ : 70° 12′). The quantity available is said to be sufficient only for local needs.

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PUNJAB.

A brief report on the iron resources of the Punjab was compiled in 1883 by Oliver (**1332**—1). Iron ore is said to occur among the metamorphic rocks of the sub-Himalayan group almost everywhere between the Jumna and Ravi rivers. The want of fuel is said to be the chief obstacle to the development of the industry.

Bashahr.—Several 'iron mines' are marked in the Atlas of India near the village of SHELE (31° 9′ : 77° 43′). According to Medlicott (**1197**—5, 178), the ores are magnetic and micaceous iron occurring in metamorphic rocks. This is the locality alluded to by Gerard (**647**—3, 364). The mines, he says, are numerous, but are only worked during three months in the year (**B.** 405).

Gurgaon.—The process of iron smelting at FIROZPUR (27° 47′ 30″ : 77° 0′) was described in 1831 by A. E. (**524**—1). The ore used is said to have been a mixture of brown hematite brought from the Narnaul district in Patiala with lateritic hematite obtained locally. Twenty-three furnaces, turning out about 2 tons of iron daily, are said to have been at work previous to the year 1836 (**B.** 406).

Jhang.—KIRANA HILLS (31° 58′ : 72° 45′). According to Fleming (**591**—5, 446; —8) and Purdon (**1443**—1), the rocks forming the Kirana hills are traversed in places by numerous veins of white quartz containing layers of rich hematite. Heron, however, who examined this area in 1909, reports (**830**—2, 235) that the veins are few in number, and that neither the purity nor amount of the ore would justify exploitation. Specimens of the ore analysed by Piddington (**1405**—53;—58) contained :—Fe=15·29 : SiO_2=11·22 : $CaCO_3$=65·14 per cent. with a trace of manganese (**B.** 404).

Kangra.—Some general information on the iron resources of the district is given by Gerard (**651**) and Paske (**1371**). A more detailed report by Marcadieu (**1168**—1) gives particulars of the iron ores worked in the neighbourhood of DHARMSALA (32° 14′ : 76° 23′). They occur as magnetic particles disseminated through talcose schists, and require concentration by washing before being smelted. The deposits near BIR (32° 3′ : 76° 47′ 30″), where about 100 furnaces were at work, were considered to be the most promising.

Similar deposits at KOHAD (32° 5′ : 76° 52′) in Chota Bhagal have been reported on by Warth (**1892**—6)—(**B.** 404).

Magnetic iron ores of the same character also occur in the Kulu valley, according to Cunningham (**399**—3, 205) and Marcadieu

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(**1168**—3). Here the matrix of the ore is a dark micaceous schist. Marcadieu formed a high opinion of the value of the ores, and advocated the establishment of iron works at BAJAURA (31° 51′ : 77° 13′).

In the Spiti valley, Hayden (**793**—9, 102) has recorded the occurrence of a band of red hematite among the Cambrian beds about 3 miles to the S.W. of MUTH (31° 57′ 30″ : 78° 6′). In the absence of fuel, the deposit is of no economic value.

Patiala.—According to Bose (**173**—21, 57), iron ore occurs in quantity at the following localities in the Narnaul district:—

(1) Two or three bands of magnetite with hematite occur in a low ridge running south from CHHAPRI (27° 56′ : 76° 9′ 30″) to JAUNPUR, a distance of 2½ miles. The bands average 7 ft. in thickness. On analysis an average sample yielded:—Fe=57·42 : S=0·15 : P=0·42 : SiO_2=9·38 per cent.

(2) Near DHANOTA (28° 0′ 30″ : 76° 4′). Hematite with magnetite in association with gneiss of a granitoid type.

(3) SOHLA (28° 15′ : 76° 5′ 30″). Hematite in association with disturbed and crushed ferruginous quartzites occurs about a mile to N. N. W. of the village.

Sirmur.—About the year 1880, a blast furnace was erected at NAHAN (30° 34′ : 77° 21′) by the Raja of Sirmur, designed for an outturn of 50 tons of pig iron a week. Ball (**71**—45, 405) gives a brief account of the inception of the undertaking, but no report on its further progress appears to have been published. The ore used is said to have been magnetite, probably mixed with specular ore, brought from CHAITA (30° 48′ : 77° 25′ 30″), 24 miles distant. The fuel and flux had also to be brought from a considerable distance.

Blane (**145**, 61) states that iron ore is said to be found in great abundance near the great LAKANDI(?), and is smelted to a small extent. It is said to produce about 25 per cent. of metal.

RAJPUTANA.

Ajmer.—Hacket (**730**—4, 248) mentions some old iron workings near the jail at AJMER (26° 28′ : 74° 41′), and remarks that the production must have been very small (**B.** 396).

Alwar.—BHANGARH (27° 5′ 30″ : 76° 21′) and RAJGARH (27° 14′ : 76° 41′). Iron ores occur in large quantities near the base of the Arvali series, according to Hacket (**730**—2, 91 ; —4, 248), and have been worked on an extensive scale. The ore from Bhangarh consists of a mixture of limonite and magnetite with oxide of manga-

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nese, containing 59·67 per cent. Fe, and 12·7 per cent. Mn. The charges of the native furnaces are said to have been exceptionally large, producing blooms of 200 to 280 lb. in weight in 20 hours (**B.** 396).

In 1884 the ores at Rajgarh were described by Andresen (**31**) as forming a regular belt 500ft. in width, and extending for a mile and a half. The deposit had been excavated to a depth of 120 feet.

Bundi.—Bhairompura (25° 31′ : 75° 46′). Hacket (**730**—4, 248) states that iron ore was being worked here in 1880, but gives no further particulars.

Jaipur.—Karwar (26° 38′ 30″ : 77° 6′). An abandoned iron mine is mentioned by Hacket (**730**—4, 248). The ore is said to be of superior quality.

Raialo (27° 5′: 76° 16′ 30″) and Nimla (27° 4′ 30″: 76° 19′). The presence of large quantities of hematite in the Raialo marbles near these places has been reported by Heron (*see* Hayden, **793**—28, 19). The deposits occur in lines of lenticular masses, varying from iron-stained marble to nearly pure hematite. Bands of pure ore 7 to 8 ft. in width were measured.

Raipur (27° 44′ 30″ : 76° 1′). Two vertical bands of massive hematite, varying from 3 to 15 ft. in width, were observed here by Heron (*see* Hayden, **793**—31, 20). The bands occur in mica schist, and are traceable for 2 miles along the strike.

Kishangarh.—Kanchria (26° 32′ : 74° 56′ 30″). An occurrence of titaniferous iron ore, formerly smelted by the natives, has been brought to notice by Holland (*see* Vredenburg, **1854**—8). The ore occurs abundantly in large well-shaped crystals, with quartz and calcite, in a broad vein traversing granitoid gneiss, about a mile to E. by N. of the village.

Mewar (Udaipur).—Gangar (25° 3′ : 74° 40′). Hacket (**730**—4, 248) states that iron ore was being worked here in 1880, but gives no particulars of its mode of occurrence.

UNITED PROVINCES.

Kumaon.—Although much has been written on the subject of the wide diffusion of iron ores in the Kumaon division, and although more than one attempt has been made to establish an iron-smelting industry on modern lines, we are still without precise information

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regarding the quantity of ore available, or its value from a commercial point of view. Several of the earlier travellers in the Himalaya,—Hardwicke (**765**, 341) in 1799, Traill (**1797**—3, 158) in 1828, and Glasfurd (**661**, 473), mention the prevalence of iron-smelting by the hill men, and give details of the process ; but Herbert (**827**—6, 250 ; —10, ciii, cxxiv) was the first to describe the nature of the ores and their general distribution.

Two classes of ores, of very different ages, may be distinguished :—

(*a*) Bands of hematite, and disseminated grains of magnetite, associated with the metamorphic schists and limestones of the outer Himalaya, probably corresponding in age with the Dharwarian rocks of the Indian Peninsula.

(*b*) Beds of hematite and limonite, constituting, as Medlicot (**1197**—5, 178) and Middlemiss (**1219**—10, 86) have shown, the more highly ferruginous portions of the bands of clay that occur in the lower part of the Nahan group, one of the divisions of the sub-Himalayan Tertiary system. It is not improbable that local surface enrichment of the ferruginous clay bands is the cause of the development of these masses of ore, and that they do not descend to any considerable depth.

Between the years 1850 and 1871 the iron resources of Kumaon attracted much attention, and the following reports were drawn up for the information of Government :—

1850. Beckett (**94**). Describes the ores in the Simalkhet area in Garhwal, and the operations of smelting and refining the metal.

1855. Henwood (**825**—1, 11). A general report on the mineral resources of the division.

1855. Drummond (**504**—6). Gives results of an exploration for iron ore along the foot of the Himalaya.

1855. Sowerby (**1679**—1). Describes the occurrences of iron ore in the neighbourhood of Dechauri.

1855. Watson (**1900**). A report on the Dechauri deposits.

1856. Barratt (**80**—1, 70). Gives particulars of newly discovered iron mines in Garhwal.

1856. Sowerby (**1679**—2 ; —3). Results of a detailed examination of the iron ore deposits in the sub-Himalayan zone.

1869-71. Lawder (**1040**—1, 87 ; —2, 19). Cursory notes on specimens of iron ore obtained from various localities.

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1871. Henwood (825—3, 18). A summary of his report on the metalliferous resources of the division.

The particulars given by Atkinson (48, 28) are compiled from Beckett's and Lawder's reports.

The areas mentioned are :—

Almora.—DWARA HATH—SIMALKHET (29° 47′ : 79° 29′). Veins of compact red hematite in clay slate, varying from 2 to 30 ft. in width. The veins have been traced for a distance of more than 15 miles from S. to N.

PONAAR VALLEY (29° 31′ : 79° 57′). Beds of massive brown hematite in clay slate, varying from 1½ to 3 ft. in thickness.

Garhwal.—NAGPUR PARGANA (30° 30′ : 79° 15′). Numerous lodes of micaceous hematite associated with quartz. Some of the lodes are said to attain a thickness of more than 50 feet.

Naini Tal.—DHANIAKOT (29° 30′ : 79° 31′). Mines have been worked at several places in the valley of the Kosila R. in this neighbourhood. The ores are usually specular or micaceous hematite, occurring in calcareous slates with thick beds of quartz.

RAMGARH (29° 26′ : 79° 37′). Several bands of micaceous hematite, varying in thickness up to 10 or 12 ft., one of which has been traced for a distance of 7 miles. The ores are associated with talcose and clay slates.

Sub-Himalayan zone :—BIJAPUR, near HALDWANI (29° 13′ : 79° 35′). Ore occurs in the joints of a bed of talcose clay 20 ft. thick, and in nodules. It is said to be of excellent quality.

DECHAURI (29° 22′ 30″ : 79° 23′ 30″). Sandstone impregnated with scaly hematite, extending to 20 or 30 feet in width.

JHAM, near HALDWANI. Occurrence similar to that at Bijapur. A bed of ore 3 to 4 ft. thick had been intersected by a pit.

LOHA BHABAR, near KALADHUNGI (29° 17′ : 79° 24′ 30″). Two beds of argillaceous sandstone passing into brown hematite, 10 and 12 feet thick respectively.

The observations hitherto made on these ores appear to have been confined to an examination of the outcrops, and no thorough sampling of the deposits in depth, such as would now be considered necessary to determine their real value, has been attempted. From a report made by Hughes (888—13) in 1874, it appears that specimens of the Ramgarh ores yielded from 42·93 to 61·33 per cent. of iron. Specimens from near Kaladhungi and Dechauri yielded 38·82 and 55·13 per cent. respectively.

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In 1856 a report on the feasibility of establishing iron works in Kumaon was drawn up by Strachey (**1717**—11), when Dechauri was recommended as the most favourable site for the purpose. In 1857 the erection of furnaces at that place was taken in hand, under the direction of Sowerby, who subsequently published details of the experiments and of the plant in use (**1679**—2, 89 ; —6, 57). About the same time works which had been erected at KHURPA TAL (29° 22′ : 79° 28′) were taken over by a private company. These two undertakings were amalgamated in 1862 under the title of the North of India Kumaon Iron Works (Ltd.). A history of the operations has been given by Atkinson (**48**, 29), and the causes which led to the failure of the enterprise have been discussed by Oldham (**1326**—26) and Warth (**1892**—9 ; —10). A final attempt to utilise the iron ores of Kumaon was made, under the superintendence of Mr. A. Campbell, in 1877 to 1879 ; but the expense incurred in the carriage of the siliceous ores from the Ramgarh area, which it was found necessary to add to the aluminous ores of Dechauri, led to the abandonment of the works (**B.** 406).

Mirzapur.—KORCHI (24° 5′ : 83° 20′). Mallet (**1159**—5, 22) has recorded an occurrence of magnetite to the north of the village. The ore band is composed of alternate arenaceous and ferruginous layers, the latter being granular magnetite.

The production of iron ore in the United Provinces is at present exceedingly small. During the five years 1909 to 1913, the average annual output amounted to no more than 24 tons.

IRON OCHRE *see* **OCHRE.**

IRON PYRITES *see* **SULPHUR.**

IRON SULPHATE *see* **SULPHATES—IRON.**

JADESTONE.

BURMA.

Myitkyina.—TAWMAW (25° 42′ : 96° 17′). The mineral jadeite, a silicate of soda and alumina, has been worked for an unknown period at this locality and in the neighbourhood, mainly for export to China, where it is highly prized on account of its supposed magical qualities. The earliest description of the mines was published by Griffith (**709**—4, 87) in 1847. The stone, he says, is found in rounded boulders embedded in yellow or orange coloured clay, and is extracted from pits not more than 20 ft. deep. The revenue derived from

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the mines in 1836, the year previous to his visit, is said to have been about Rs. 40,000 (£2,666). The mines are also mentioned by Hannay (**760**—6, 11 : **1385**, 265), but he does not appear to have visited them (**B.** 518).

After the annexation of Upper Burma the mines were visited and described by Noetling (**1211**—8, 134 ; —10 ; —23), who observed that in addition to the boulder deposits seen by Griffith, jadeite had been discovered *in situ* in a dark coloured serpentinous rock, intrusive in Tertiary (probably upper Miocene) sandstones and clays.

More recently (1907), a full description of the geology of the area, and of the mode of occurrence of the jadeite, with remarks upon the petrology of the rocks associated with it, has been given by Bleeck (**151**—1 ; —3). The mineral is shown to occur as a compound dyke, consisting of jadeite and albite with an outer border of amphibolite, intruded into serpentine under conditions of high compression. The jadeite occupies the centre of the dyke, and is of a pure white colour, with included green patches of varying shades, which are the portions sought for.

Boulders of jadeite are also quarried from Tertiary conglomerates at HWEKA (25° 29′ : 96° 20′), and from the alluvial deposits of the URU (UYU) R. near MAMÔN (25° 36′ : 96° 18′). Their occurrence in the Tertiary beds proves, as Bleeck points out, that the jadeite intrusions belong to a far earlier period than that assigned to them by Noetling.

The mineralogical characters of the jadeite of Tawmaw, and of the rocks associated with it, have been discussed by Bauer (**88**—1 ; —8), Krenner (**1013**—1; —2), and Fischer (**586**—1 ; —3). Analyses of the mineral have been published by Damour (**413**—1 ; —3), Farrington (**566**), and White (**1922**).

The average annual production of jadeite in Upper Burma, during the five years 1909 to 1913, amounted to 2,109 cwt. In 1914 and 1915 the amounts produced were 3,764 cwt. and 3,692 cwt. respectively.

CENTRAL INDIA AGENCY.

Rewah.—PIPPA (23° 58′ 30″ : 82° 45′). According to Mallet (**1159**—5, 20), bands of hornblende rock passing into jade are associated with the corundum quarried at this locality.

MADRAS.

Arcot (S.).—A mineral resembling jade is mentioned by Leschenault de la Tour (**1062**—1, 333) as occurring about 2½ miles to the

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W. of TIRNAVALOUR (TIRUVANANALLUR, 11° 51′ 30″ : 79° 25′ 30″), on the road from Pondicherry to Salem. The rock is described as of a beautiful apple green colour mottled with red and greyish patches, and is said to take a high polish. In another place (**1062**—2, 248), the mineral is referred to as jasper.

TIBET.

Cohen (**333**) and Bauer (**88**—3 ; —6) have described the mineralogical characters of specimens of jadeite brought from Tibet. They probably occur as boulders in alluvial despoits, but the locality from which they come is not known.

TURKISTAN.

The celebrated jade mines situated in the Karakash valley, about 20 miles to the S. E. of SHAHIDULA (36° 20′ : 78° 0′), have been described by H. v. Schlagintweit (**1578**—15 ; —17) and Stoliczka (**1712**—27). The jade is associated with a white, coarsely crystalline mineral resembling albite, but infusible before the blowpipe, forming veins in mica and hornblende schists. The colour varies from white to pale and dark green. The pale green variety sometimes attains a thickness of 10 ft., but is greatly fractured in all directions. The quarries had been abandoned since the year 1864 (**B.** 517).

An analysis of jade from the Kuenlun mountains has been published by Allen (**24**).

JASPER *see under* **GEM-STONES.**

KANKAR *see under* **BUILDING MATERIALS.**

KAOLIN *and* POTTERY CLAY.

The following notes refer only to the finer varieties of clay, suitable for the manufacture of chinaware or art pottery. The coarser kinds of clay, so largely used by the native potters for making unglazed cooking utensils, water jars, and the like, are to be found in the immediate neighbourhood of nearly every village throughout India and Burma, and require no further notice.

ASSAM.

Hannay (**760**—5, 336) gives a brief account of the principal deposits of white clays in Upper Assam. Extensive beds of pure kaolin were seen on the DORA R. (27° 54′ : 96° 20′) in Lakhimpur (*see also* Dalton and Hannay, **408**, 91). Fine white clays are also

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mentioned as occurring at the falls on the NAMBOR R. (26° 24′ : 93° 56′); on the DHANSIRI R.; and at BOR PATHAR (26° 17′ 30″ : 93° 56′) in Sibsagar.

Garo Hills.—Bedford (**96**—2, App. ii) records the occurrence of pipe clay in the hills near DOMALGIRI (25° 32′ : 90° 10′ 30″) and MAHENDRAGANJ (25° 17′ 30″ : 89° 55′). Medlicott (**1197**—33, 61) and La Touche (**1034**—8, 42) found that beds of indurated white clay are widely distributed through the western portion of the hills, occurring in seams of 2 or 3 ft. in thickness near the base of the Cretaceous series. They are largely developed at TURA (25° 31′ : 90° 17′), where the clay is used for white-washing (**B.** 567).

BENGAL.

Bankura.—Homfray (**866**—2) notes the occurrence of white porcelain clay at the foot of the hills south of the Damuda R. near MALLIARI (23° 28′ 30″ : 87° 17′), and on the road to BANKURA (23° 14′ : 87° 8′). Kaolin resulting from the decomposition of felspar porphyry was also observed by Ball (**71**—46, 112) on the Bankura road, about 7 miles to the S. of Raniganj.

Burdwan.—Clays derived from the Damuda coal measures have been used with success at pottery works in RANIGANJ for the manufacture of earthenware, tiles, drainage pipes, etc., (**B.** 565).

Darjeeling.—Some of the Daling slates, according to Mallet (**1159**—6, 90), decompose into a white clay which might be used for pottery. It is said to occur in quantity near the mouth of the SUKKAM STREAM.

A bed of kaolin, about 6 ft. thick, met with in excavating the site for the European hospital at DARJEELING, has been specially described by Mallet (**1159**—31, 58). A small sample, when tested, fused to a transparent white enamel.

BIHAR AND ORISSA.

Bhagalpur.—COLGONG (25° 16′ : 87° 18′). A report on the clays of this neighbourhood, drawn up in 1864 by H. F. Blanford, is quoted by Stuart (**1723**—3, 142). They occur in two isolated hills, rising abruptly from the alluvium on the right bank of the Ganges at KARDEH and PATARGHATTA, a few miles below Colgong. The principal bed of kaolin, which is found near the base of the hills, has been formed directly by the decomposition of the underlying gneiss, and ranges in thickness from 40 to 100 ft. The upper portion of the

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hills, which rise to heights of 400 and 180 feet respectively, is made up of alternating beds of clay and sand, all of which would furnish materials for pottery making. The thickness of fine clay is estimated at about two-ninths of the whole thickness exposed.

An analysis of the kaolin from the base of the hills gave the following result:—Water and organic matter =14·00 : SiO_2= 57·00 : Al_2O_3=39·11 : $CaCO_3$=1·42 : MgO=1·21 : Na_2O and K_2O= 1·26 per cent.

Pottery works were established in 1860 at Patarghatta by Macdonald, but were closed on his departure in 1864. The articles produced are said to have been of the highest quality, including table ware, porcelain for scientific purposes, etc.; but no record of the operations appears to have been published.

Cuttack.—Blanford (**148**—2, 279) mentions the occurrence of beds of white clay in the Rajmahal group at KUKKER (KAKARI, 20° 30′ : 85° 50′) and NARAJ (20° 28′ : 85′ 50′), on the banks of the Mahanadi. The clay was used for dressing leather and as whitewash. Stirling (**1706,** 178) mentions similar clays in the neighbourhood of KHURDA (20° 11′ : 85° 41′), to the south of the Mahanadi.

Beds of white lithomarge occur in places, according to Blanford (*l. c.*) beneath the coastal laterite, but are apt to be stained by ferruginous matter (**B.** 564).

Manbhum.—Impure kaolin, resulting from the decomposition of granite veins and gneiss, occurs in considerable quantity, according to Ball (**71**—46, 112). The abundance of kaolin in this and the adjoining districts is also alluded to by Hewitt (**833,** 419).

Mayurbhanj.—The clays underlying the laterite about BARIPADA (21° 56′ : 86° 47′) are stated by Bose (**173**—20, 172) to be well suited for pottery making. A sample tested by Vredenburg became intensely hard without fusing, and assumed an agreeable terra cotta colour.

Santal Parganas.—RAJMAHAL HILLS. In 1831, Buchanan-Hamilton (**222**—19, 2) drew attention to the abundance of white-pottery clays obtainable in the Rajmahal hills. The most important deposits are said to occur at KHARIPAHAR(?), near the south end of the range, and in the neighbourhood. This locality, as well as LOHARIA (? LOHANDIA, 25° 3′ : 87° 26′) is also mentioned by Oldham (**1326**—6, 281).

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More recently (1907-08) an examination of these deposits was made by Stuart (**1723**—3). The clays were found to occur in three ways :—

(*a*) As the decomposition product of felspar in the fundamental gneisses and schists.

(*b*) In white Damuda sandstone, resulting from the decomposition of felspar originally present in the sandstone.

(*c*) Beds of white clay interbedded with the Damuda sandstones.

The more important deposits of class (*a*) were seen at :—

DODHANI (24° 16′ : 87° 27′ 30″). Bed more than 10 ft. in depth and 30 ft. in width.

KARANPUR (24° 19′ 30″ : 87° 27′). Bed over 6 ft. in depth, but becoming less pure below this depth.

KATANGI (24° 28′ : 87° 29′). Bed over 15 ft. in depth, exposed for a length of 50 yards.

Smaller exposures were seen near BAGMARA (24° 38′ : 87° 21′ 30″), BHUKHANDA (24° 20′ : 87° 24′), and in a stream bed near RAJABHITA (24° 41′ : 87° 29′).

A sample from Dodhani contained :—SiO_2=54·5 : Al_2O_3=39·6 : H_2O=5·9 per cent. When tested, the clay withstood a temperature of about 1,600°F. without fusion.

Clays of the second class (*b*) are found wherever the Damuda sandstones are exposed along the western margin of the hills, especially in the Hura, Dhamni, and Chuperbhita coal fields. The most conveniently situated locality is MANGAL HAT (25° 6′ : 87° 50′), where the clay extracted from the sandstone by crushing and washing is used by the Calcutta Pottery Co.

The third form of clay (*c*) is found a quarter of a mile to the W. of PIARAM (25° 0′ : 87° 27′) in the Hura coal field, where it forms a bed 4 to 5 ft. in thickness, and to the S. of the streams by HURA (24° 59′ : 87° 27′). A sample from Piaram contained :—SiO_2=59·5 : Al_2O_3=39·4 : Alkalies and loss=1·1 per cent.

BOMBAY.

Rewa Kantha.—Clays suited for the manufacture of high class pottery are stated by Bose (**173**—23, 186) to occur in the Tertiary beds exposed in the Jhagadia and Valia Taluks, Rajpipla State. The best specimens were met with to the W. of DAMLAI (21° 42′ : 73° 16′ 30″).

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BURMA.

Henzada.—Some of the upper beds of the Nummulitic group consist mainly of china clay almost free from iron, according to Theobald (**1763**—16, 341). A sample from near ENDEINGON (17° 59′ : 95° 10′) was found by Tween to contain 76 per cent. of kaolin and 23·4 per cent. of silica (*l. c.*, p. 294).

Mergui.—Helfer (**808**—5, 35) records the occurrence of a considerable layer of kaolin on the bank of the Tenasserim R., four days' journey above TENASSERIM (12° 5′ : 99° 3′)—(**B.** 567).

CENTRAL INDIA AGENCY.

Gwalior.—Kaolin quarries at ANTRI (26° 3′ : 78° 16′ 30″) are mentioned in a report on the geology of Gwalior submitted by Jones (*see* La Touche, **1034**—39, 113).

Rewah.—The white clays noted above under the heading **FIRE-CLAY,** as occurring in the neighbourhood of UMARIA, are well suited for the manufacture of pottery. Their mode of occurrence and properties have been described by Mallet (**1159**—52, 142).

CENTRAL PROVINCES.

Jubbulpore.—Mallet (**1159**—52) has described the occurrence of white clays in the neighbourhood of JUBBULPORE (23° 11′ : 80° 0′), where they are interstratified with upper Gondwana sandstones. In places the beds of pure clay are from 4 to 5 ft. in thickness, and they cover a wide area, especially near Chota Simla. Samples when exposed for an hour to a white heat were found to be quite infusible, and to have become intensely hard. The composition was :—SiO_2=46·00 : Al_2O_3=40·77 : Loss on ignition=13·23 per cent.

About the year 1890 pottery works were established at Jubbulpore by Messrs. Burn & Co. of Calcutta, and more recently by the Perfect Pottery Co.

Raipur.—White shales associated with the Chandarpur sandstones at MURKATOLA (20° 19′ 30″ : 81° 38′) are largely used locally as white-wash, and are considered by Bose (*see* Griesbach, **708**—31, 39) to be suitable for pottery making.

MADRAS.

For a general account of the manufacture of high class pottery in Madras, reference may be made to an article by Chisholm (**311**) in the *Asiatic Quarterly Review.*

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Arcot (N.).—Patches of kaolin, derived from the decomposition of felspathic gneiss, occur in several places, according to Foote (**596**—20, 207), but are not sufficiently extensive to be workable. A supply of pure water would also be difficult to obtain. Hunter (**894**—1) mentions the occurrence of a bed of this description at PAUPANTANGALAM, near ARCOT (12° 54′ : 79° 23′)—(**B.** 563).

Arcot (S.)—Blanford (**147**—8, 213) has noted the occurrence of fine plastic clay in the Cuddalore beds south of the Gudalam R. opposite PANROTI (11° 46′ 30″ : 79° 37′). The clay contains small quantities of lime and iron, giving it a pinkish tint, which becomes darker on burning. Kaolin was also found in a well at SEMANGALAM (12° 4′ : 79° 46′)—(**B.** 562).

Chingleput.—White clays and shales are extensively developed in the Rajmahal series, according to Foote (**596**—8, 132), especially near SRIPERMATUR (12° 58′ : 80° 1′) and in the valley of the Attrampakkam stream. The Madras School of Art formerly obtained a supply from a deposit at COOPUM, near PERUMALPUT (PERUMALLAPALLA, 13° 7′ : 80° 3′). Hunter (**894**—1) has given an account of experiments in pottery making carried out at CHINGLEPUT (12° 42′ : 80° 2′)—(**B.** 563).

Godavari.—Benza (**110**—4, 54) states that patches of porcelain earth are found in the alluvium of the Godavari near RAJAMAHENDRI (17° 0′ : 81° 50′), and are used in the manufacture of fine pottery, much esteemed all over India.

Nilgiri.—Benza (**110**—1, 421 ; —3, 248) mentions the occurrence of thick beds of procelain earth in the neighbourhood of DODABETTA (11° 23′ : 76° 48′), derived from the decomposition of pegmatite veins.

South Kanara.—The discovery of an extensive deposit of pure porcelain clay on the BULAR R., a few miles to the N. of MANGALORE (12° 52′ : 74° 53′) was reported in 1842 by Christie (**313**—2). The deposit is also mentioned by Bushby (**246**)—(**B.** 563).

Trichinopoly.—The Cretaceous formation contains several beds of fine clay well adapted for the manufacture of pottery. The following localities are mentioned by Blanford (**147**—8, 212) :—On the slope of the high ground S. E. of VEMMANY (11° 14′ : 79° 7′); also at COOTHOOR (11° 13′ : 79° 9′ 30″) and UTACOIL (11° 11′ 30″ : 79° 10′).

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A thick bed of pipe clay was also observed between PERANY (11° 6′ : 78° 56′) and KAURAY (11° 8′ : 78° 56′ 30″)—(**B.** 562).

Vizagapatam.—King (**987**—33, 156) mentions the occurrence in wells near VIZIANAGRAM (18° 7′ : 83° 28′) of partially decomposed felspar or 'Cornish stone.' Samples tested by Mallet were reduced at a white heat to a semi-fused condition, the colour after cooling being pure white.

MYSORE.

Bangalore.—Campbell (**272**—7) states that a bed of white kaolin earth is usually found between the red surface soil of the Mysore tableland and the underlying hornblendic granite. It is said to extend from BANGALORE (12° 58′ : 77° 38′) to NANDIDRUG (13° 22′ : 77° 45′), and to be several feet thick in places. The clay was found to answer well for making crucibles, when mixed with an equal quantity of powdered quartz (**B.** 563).

Venkataramaiya (**1838**—4) has reported on a deposit of this nature at TINNALU (13° 4′ 30″ : 77° 37′ 30″). The bed of clay covers about 42 acres, but its thickness is not great. It is said to be suitable only for brick making.

Chitaldroog.—Red and white mottled clays are largely quarried in the Jagalur Taluk and near CHITALDROOG (14° 13′ : 76° 27′). The clays, being free from grit, are considered by Sampat Iyengar (**1549**—1, 92) to be suitable for the manufacture of high class pottery.

Mysore.—Sambasiva Iyer (**1548**—11, 38) mentions the occurrence of large quantities of kaolin at MELKOTE (12° 40′ : 76° 42′ 30″), and gives details of the native methods of preparing it for the market. The clay is derived from the decomposition of muscovite gneiss, traversed by felspathic dykes.

NORTH-WEST FRONTIER PROVINCE.

Hazara.—According to Middlemiss (**1219**—17, 287), kaolin is reported to occur in the higher parts of the Khagan valley, in Upper Hazara, but nothing is known regarding the extent of the deposits.

PUNJAB.

In a monograph on the pottery and glass industries of the Punjab, Hallifax (**741**) states that the clays used are usually obtained locally from the alluvium of the plains. Details of the manufacture of white

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pottery at MULTAN (36° 12′ : 71° 32′) are given. Much information on this subject has also been given by Baden-Powell (**60**—1, Vol. II, 220).

Delhi.—Kaolin has been quarried to a small extent at KASUMPUR (28° 33′ 30″ : 77° 13′). According to Hacket (**730**—4, 249) the kaolin is derived from granite veins in the Arvali series. The clay was used for white-washing and as fire-clay (**B.** 566).

Simla.—Pottery clays, resulting from the decomposition of limestones associated with carbonaceous slates, are described by Oldham (**1324**—21, 153) as occurring on the spurs of the hills running north from Simla. They have been used for the manufacture of bricks, tiles, and coarse pottery.

RAJPUTANA.

Jaipur.—Hacket (**730**—4, 249) mentions a deposit of kaolin at BUCHARA (27° 33′ : 76° 2′), but gives no details.

Heron (*see* Hayden, **793**—28, 19) has recorded the existence of beds of kaolin at two localities :—

RASNU (26° 41′ 30″ : 76° 38′). A bed of kaolin about 20 yds. wide, white but rather impure, banded with quartzite.

At the northern end of the Lalsot hills, chiefly near DARAOLI (26° 55′ : 76° 58′). Two beds separated by quartzite. The upper bed consists of white and fairly pure clay, slightly mottled with pale purple and pink.

UNITED PROVINCES.

Farrukhabad.—About the year 1838 pottery works were established at FATEHGARH (27° 22′ : 79° 41′) by Mr. Jeffreys, and appear to have met with considerable success. The only published record of these works is contained in a letter by J. C. Pyle (**1445**), and in a list of the articles manufactured, by W. Pyle (**1446**). These include tableware, stoneware, fire-bricks, glazed tiles, etc. (**B.** 566).

KIESERITE *see* **SULPHATES—MAGNESIUM.**

KYANITE *see under* **GEM-STONES.**

LANGBEINITE *see* **POTASH SALTS.**

LAPIS LAZULI *see under* **GEM-STONES.**

LATERITE *see under* **BUILDING MATERIALS BAUXITE** *and* **IRON.**

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LEAD and SILVER.

AFGHANISTAN.

Drummond (**504**—2, 91) mentions the occurrence of lead ores in the districts of the Hazara Jat, Ghorband, Wardak, Bangesh, and the Safed Koh.

Griesbach (**708**—4, 57) states that lead ores are common in many localities in southern Afghanistan, occurring near the boundary of the Cretaceous limestones with igneous rocks. Galena is said to be brought from the SHAH MAKSUD RANGE (31° 50′ : 65° 15′) and the TIRIN VALLEY (33° 0′ : 66° 40′), and to occur in quantities in the Hazara Jat. In another paper (**708**—21, 77), Griesbach mentions the occurrence of traces of galena near URSUK (33° 39′ : 68° 48°) and ZANAKHAN(?) in Kharwar.

An ancient lead mine at FARANJAL (35° 0′ : 68° 44′) in the Ghorband valley was described in 1838 by Lord (**1091**—2, 533). The workings are said to be very extensive, and to be laid out with considerable skill. The ore was believed to occur in a schistose layer at the junction of quartzites with overlying conglomerates ; but according to Collins (**343**), who visited the mine in 1893, it occupies a large fissure vein filled with breccia, traversing limestones and shales probably of Carboniferous age. Samples of the ore yielded on assay 68 per cent. of lead, and 1½ oz. of **silver** per ton of lead.

Fragments of galena were also noted by Lord in the Ghorband valley below KINCHAK (35° 3′ : 68° 51′), but were not found *in situ* (**B.** 302).

ASSAM.

Bor Kamti.—Specimens of argentiferous galena from the Bor Kamti country, lying to the E. of Upper Assam, are mentioned by Maclaren (**1134**—2, 184). The ores probably occur in crystalline limestone.

BALUCHISTAN.

SAINDAK (29° 16′ : 61° 33′). Vredenburg (**1854**—1, 293) mentions the occurrence of galena, associated with carbonates of copper, in veins traversing volcanic tuffs and shales and limestones of upper Eocene age. The veins are seldom more than a foot in width, and contain galena only at the widest parts.

Jhalawan.—SHEKRAN OR KAPPUR (27° 53′ : 66° 28′). Extensive mines of lead and antimony ores at this locality are mentioned by Masson (**1189**—2, 55), who says that 200 men were constantly employed in extracting the ore. When visited by Cook (*see* Hughes,

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883, 81), the mines had been deserted, but large quantities of slag were seen. According to Tipper (1787—5), the mines are situated in hard blue Liassic limestones and in rather softer beds of middle Jurassic age. The chief ore is cerussite or carbonate of lead. No silver was found in the slags. As fuel is scarce, the ore could not be smelted on the spot.

Le Messurier (1055—1) refers to the ore as sulphide of **antimony**, and says that it occurs in cubes of an inch square. The lead ore was considered to be of inferior quality and small in quantity (**B.** 302).

BIHAR AND ORISSA.

A summary of the information available regarding the distribution of lead ores in Chota Nagpur was compiled in 1891 by King and Pope (**989**, 95).

Bhagalpur.—The following localities are mentioned in the 'Economic Manual' (**B.** 288-290) :—

DUDIJOR (24° 41′ : 86° 47′). A sample of galena from near the surface is said to have yielded 71 per cent. of lead and 42 oz. 3 dwt. of **silver** per ton of lead. A mine was opened in 1879, but no particulars of the working are available. Lead ore is said to occur also at GONORA, KARDA, and KEJURIA, in the same neighbourhood. Samples from the last named locality yielded 12 per cent. of lead, and 46 oz. 4 dwt. 3 gr. of **silver** per ton of lead.

GAURIPUR or PHAGA (24° 49′ 30″ : 87° 0′). A shaft was sunk here in 1878 on a vein of lead ore to a depth of about 30 ft. Three samples of the ore yielded on the average 71·7 per cent. of lead, and two of these are said to have contained 58 oz. and 103 oz. 2½ dwt. of **silver** per ton of lead respectively.

KHARIKHAR (24° 50′ : 86° 52′). A specimen of galena from this locality contained 52 oz. 8 dwt. 14 gr. of **silver** per ton of lead. No account of the extent of the deposit has been published.

Hazaribagh.—Fragments of cerussite are reported by Mallet (**1159**—7, 35) to have been found near the villages of MEHANDADI and BARHAMASIA (24° 20′ : 86° 18′) ; also near KHESMI and NAUWADIH (24° 24′ : 84° 26′).

Galena is said (**B.** 292) to have been found in the copper mine at BARAGUNDA (24° 5′ : 86° 7′); and Mallet (**1159**—7, 34) found

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traces of galena disseminated through a vein of garnet and coccolite in the Patru stream, to the N. E. of GULGO (24° 24′ : 86° 25′ 30″).

HISATU (23° 59′ 30″ : 85° 4′ 30″). The existence of lead ore at this locality was discovered in 1777 by Motte and Farquhar (*see* Heatly, **801,** 554). In the Statistical Account of Bengal (**896**—2, Vol. XVI, 164) it is stated that the deposit was worked for **antimony** towards the end of the century. In 1842 the mine was re-discovered by Ouseley (**1349**—4), who sent specimens of the ore to Calcutta, which were analysed by Piddington (**1405**—13; —23). They were found to contain 47·02 per cent. of lead and 4·7 per cent. of **antimony,** but no trace of **silver** was detected. The nature and extent of the deposit do not appear to have been ascertained (**B.** 293).

NYATAND (24° 30′ : 85° 46′). A lead mine at this place is indicated on Sherwill's map of Bengal (**1625**—11), but no particulars are known (**B.** 292).

PARSEYA (24° 10′ : 85° 51′). Large rolled masses of vein stuff with galena have been washed out of the alluvium of the river near the village, but no traces of the ore *in situ* have been found (**B.** 293).

Manbhum.—Ball (**71**—8) has recorded the discovery of a vein of galena in a hill situated close to the village of DEKIA, about a mile to the E. of DHADKA (22° 48′ : 86° 34′). The ore occurs in lenticular masses 5 or 6 inches in length, surrounded by brown hematite and quartz, in what appears to be a true lode traversing mica schists. On analysis specimens of the ore yielded 79 per cent. of lead, and from 76·34 oz. to 119 oz. of **silver** to the ton of lead (**B.** 290).

This deposit, with others of the same character at KUSHBONI, JHANIJHORE, LATAPARAH, LEWSHAI, PARADA, GHAGRA, and NANNAH, were thoroughly prospected by Messrs. Mackinnon, Mackenzie & Co., of Calcutta, in 1904 and 1905, and were found to be mere pockets of ore. From a similar deposit at BELDI (22° 56′ 30″ : 86° 21′ 30″) 267 tons of ore were extracted, which yielded 91 tons 9 cwt. of lead, 4,716·15 oz. of **silver,** and 86·04 grs. of **gold** (**862**, 126).

Monghyr.—Sherwill (**1624**—2, 206) mentions the discovery of a vein of argentiferous galena at the base of the Kharakpur hills, but the exact locality is not known. The ore is said to be rich in **silver** (**B.** 290).

Palamau.—Weathered fragments of galena are said to have been picked up on the surface near the village of BARIKHAP (23° 52′ 30″ : 84° 52′ 30″), but the mineral has not been found *in situ* (Ball **71**—32, 125 ; **B.** 294).

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Ranchi.—SILI (23° 21′ : 85° 54′). Fragments of galena from this neighbourhood are preserved in the Geological Survey Museum, but no further particulars are known (**B.** 294).

Sambalpur.—JHUMAN (? JUMARI, 21° 32′ 30″ : 83° 54′). The discovery of a vein of galena in the bed of the MAHANADI R. at this place has been recorded by Ball (**71**—29, 191). The ore occurs in a vein of quartz, 16 to 19 inches in width, traversing granitoid gneiss, and in places occupies the whole width of the vein. A length of about 6 ft. was exposed by excavation. The galena contained 12 oz. 5 dwt. of **silver** per ton of lead (**B.** 295).

TALPUCHIA (21° 56′ : 84° 5′). Rolled pebbles, consisting of a mixture of the oxides and carbonates of lead, have been found on the surface to the south of the village, and may have been derived from a small hill lying to the north (Ball, **71**—29, 192). The specimens yielded 87·28 per cent. of lead (**B.** 295).

Santal Parganas.—AKASI or PANCH PAHAR (24° 37′ 30″ : 87° 15′). A vein of lead ore is marked in this position on Sherwill's map of Bengal (**1625**—11). According to McClelland (**1117**—33, 32), the ore occurs in small crystals in a decomposing bed of quartz and actinolite, constituting about 2 per cent. of the mass. Buchanan-Hamilton (*see* Martin, **1181**, Vol. II, 188) describes the ore as sulphide of antimony, and says that on excavation a vein ¼ in. in width was met with. Specimens are stated by Jones (**956**—2, 282) to yield 60 per cent. of lead.

BAIRUKI (24° 35′ : 86° 40′). The copper ores at this place were found by Piddington (**1405**—41, 10) to be associated with galena and cupro-plumbite. No **silver** was detected in the galena, but in a later paper (**1405**—47) Piddington says that he obtained 154 grs. of **silver** from 14 lb. of the copper ores. An assay of the galena quoted by Ball (**71**—45, 287) gave 82·25 per cent. of lead, and the equivalent of 35 oz. 14 dwt. of **silver** per ton of lead.

According to Barratt (**80**—2, 8), the deposit of lead ore is distinct from that of the copper, and is situated 60 fathoms to the south of the latter (**B.** 287).

SANKERA HILLS (24° 18′ : 87° 22′). A deposit of lead ore is indicated here on Sherwill's map of Bengal (**1625**—11), but the exact locality is not known. Ball suggests that it was situated in the Chandrapahar (silver hill) to the S. W. of the main mass of the hills (**B.** 286).

TURI or TIUR PAHAR (24° 30′ : 86° 54′). McClelland states that lead ore occurs here in small crystals (**B.** 287).

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Singhbhum.—Griesbach (**708**—34, 13) has recorded the discovery by F. H. Smith of an irregular vein of galena containing gold as well as silver. The exact locality is not specified, but it lies probably in the neighbourhood of PAHARDIAH (22° 30′ : 85° 16′) On assay the ore yielded 79·3 per cent. of lead, 34 oz. 2 dwt. 17gr. of **silver**, and 11 oz. 2 dwt. 3 gr. of **gold** per ton of lead.

BOMBAY.

Kathiawar.—Galena was found by Fedden (**569**—6, 134) associated with copper pyrites in a quartz vein traversing trap rock at BANEJ NES (? 21° 2′ : 70° 59′), in the Gir hills. The ore is said to occur irregularly and in very small quantity.

Rewa Kantha (Narukot).—Lead ore is mentioned in the Bombay Gazetteer (Vol. III, 197) as having been worked at JHUBAN (? JABAN, 22° 24′ : 73° 43′) and the KHANDIVAV LAKE (22° 18′ : 73° 47′); but no information as to the extent or nature of the deposits is available (**B.** 301).

BURMA.

Amherst.—O'Riley (**1340**—3, 735) states that galena and carbonate of lead are found at many places among the limestone hills that extend southwards from the PAGAH RANGE (17° 36′ : 97° 50′), between the Yenbain and Taungyin rivers, to the head waters of the HOUNDRAN (? HAUNG-THA-RAW) and ZIMME (ZAMI) rivers (15° 25′ : 98° 30′) ; but does not give the precise localities. The ores are said to have yielded from 76 to 81 per cent. of lead, and an average of 12 oz. of **silver** per ton of lead (Theobald, **1763**—19, 93).

Mallet (**1159**—38) has described a specimen of carbonate of lead received from Maulmein, containing cavities partly filled with native lead.

Bhamo.—PONSEE or PONSHI (24° 27′ : 97° 41′). The silver-lead mines at this locality, formerly worked by the Chinese, were visited and described by Anderson (**29**—2, 267 ; —3, 105) about the year 1870. The mines are situated in a hill formed of crystalline limestone, about 600 ft. in height, on the left bank of the Taping R. The ore occurs in fissures in the limestone filled with clay, and was reached by adits from 200 to 400 feet in length. It is said to contain 0·191 per cent. of **silver**, or according to Theobald (**1763**—19, 93), 73 oz. 10 dwt. of **silver** per ton of lead.

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Katha.—Veins of cerussite were found by Noetling (**1311**—13; —18, 118) traversing a band of aphanitic rock at KAYDWIN (24° 15′ : 95° 40′) on the Nam-maw R. The average thickness of the band is about 4 ft., and the cerussite occurs in thin layers along cracks in the rock. Samples of the ore yielded 69·1 per cent. of lead, and 33 oz. 16 dwt. 4 gr. of **silver** per ton of lead.

A similar occurrence was found at MAWKWIN (24° 10′ : 95° 37′), 6 miles to the S. W. of Kaydwin.

Mergui.—MAINGAY's I. (12° 32′ : 98° 18′). A lode of lead ore, occurring on the west coast of the island close to the sea, has been described by Fryar (*Ind. Economist*, V, 44 ; *Coll. Guard.*, XXIV, 254). The ore occurs with quartz and barytes in a hard, coarse, argillaceous schistose rock. Samples of the ore assayed by Tween yielded from 78·15 to 81·45 per cent. of lead, and from 11 to 13 oz. of **silver** per ton of lead (**B.** 310).

Salween.—On a sketch map of the Yunzalin valley, compiled by O'Riley and reproduced by Theobald (**1763**—19, 94), nine localities for lead ore are shown. The ore is said to occur in the same limestone formation that is exposed near Maulmein. Some of the lead mines in the neighbourhood of MIZINE (17° 18′ : 97° 40′) were visited in 1873 by Fryar (**625**—9). One of the localities mentioned by him, TEETALAY HILL, probably corresponds to the HTEESAILAY HILL shown on O'Riley's map. The ore near Mizine occurs in a siliceous gangue, very difficult to work, and yielded on assay 14 oz. 14 dwt. of **silver** per ton of lead. At Teetalay the ore occurs in limestone, and at TEETAMEELAY HILL (? THEETHKAMOODOE hill of O'Riley's map) in a quartz matrix. Ore from the last named locality contained 8 oz. 3 dwt. 8 gr. of **silver** per ton of lead (**B.** 310).

Shan States (N.).—BAWDWIN (23° 7′ : 97° 20′ 30″). These are the only really productive silver-lead mines now being worked within the limits of the Indian Empire. They are said to have been worked by the Chinese from the beginning of the 15th century, but were abandoned about seventy years ago on account of the disturbed state of the country. The old workings are very extensive, and testify to a considerable knowledge of mining practice on the part of the Chinese, who smelted the ore and extracted the silver on the spot, leaving the bulk of the lead in the form of huge heaps of slag, which cover an area of several acres.

The geology of the locality and mode of occurrence and character of the ores have been described by La Touche and Brown (**1035**),

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who visited the mines in 1907. The ores are developed along a zone of intense disturbance due to overthrust faulting in a series of rocks composed of coarse felspathic grits and rhyolitic tuffs with thin flows of rhyolite. They appear to owe their origin to a metasomatic replacement of the felspar and, in extreme cases, the quartz of the country rock by metallic minerals, probably carried in solution ; and consist mainly of galena and zinc blende, associated with small quantities of iron and copper pyrites. The constitution of the ores varies, assays from three ore-bodies yielding from 24·3 to 33 per cent. of lead, 14·2 to 29·8 per cent. of **zinc**, and 17·5 to 37 ounces of **silver** (**862**, 129).

The mines are now being worked by the Burma Corporation (Ltd.). Since the year 1909, when operations began, the lead slags left by the Chinese, containing about 50 per cent. of lead, have been removed and smelted ; and at the same time the existence of ore-bodies, below the level reached by the Chinese miners, has been proved by exploration. According to a report published in the *Engineering and Mining Journal*, (Vol. XCVII, 154), the quantity of ore reasonably assured in 1914 amounted to 1,154,000 tons.

The average annual output from the mines, during the five years 1909 to 1913, was 2,313 tons of ore and 22,452 tons of slag. In 1914 the figures were 8,769 tons ore and 24,901 tons slag ; and in 1915, 4,094 tons ore, 32,534 tons slag, and 5,620 tons gossan flux. It is said that the supplies of slag are now practically exhausted. The total production of hard lead during 1915 was 13,522 tons, of which 6,575 tons, containing 284,875 oz. of silver, were shipped to England to be refined.

Fermor (**577**—9) has recorded the receipt of specimens of lead ore from two other localities in the States :—

1. About 4 miles to the W. of NAMSAW (22° 31′ : 96° 59′). Galena with crusts of cerussite and a little quartz.
2. MAN HPWE (22° 0′ : 97° 56′ 30″). Galena scattered through finely crystalline grey limestone.

Shan States (S.).—KYAUKTAT (KYAWK HTAP, 20° 51′ : 96° 49′). The operations of smelting and cupelling lead ore found in this neighbourhood were described in 1865 by Fedden (**569**—1, 39), but he was unable to visit the mines. These were fully described in 1887 by Jones (**952**—4, 191), who says that they are situated at BAWZAIN (MAW-SÜN), BWELON, and DWINZU, a few miles to the N. and N. E. of Kyauktat. The ore is found beneath the surface covering of red clay, in yellow clay filling clefts and fissures in limestone, and occurs in blocks and fragments varying from 3 ft. across

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to the size of a pea. Cupellation was carried out in a closed furnace, in which the fire of charcoal logs was suspended above a bath of molten lead, the litharge being removed by an iron rod. In practice about 2 oz. of silver were obtained from 160 lb. of lead. On assay the ore yielded 74·29 per cent. of lead, and 13 oz. 7 dwt. 2 gr. of silver per ton of ore, with a trace of **gold.**

Middlemiss (**1219**—22, 151) mentions several lead mines in the neighbourhood of Bawzain, and in addition one in the KYAUK-KULEYWA STATE, worked by the chief of the Pwehla State. Old mines are situated at a spot 4½ miles to the N. of MYINKYARDO (20° 56′ : 96° 36′), and near PYINNYAUNG (20° 49′ 30″ : 96° 26′) on the road from Thazi to Taunggyi.

The production of lead ore in the Southern Shan States amounted on the average to 81 tons annually, during the five years 1909 to 1913. In 1914 the output was 12 tons, and in 1915, 28 tons.

Yamethin.—MT. PIMA (20° 40′ : 96° 21′). A lode of argentiferous galena, said to be from 3 to 30 feet thick, occurring in limestone among the foot-hills of Mt. Pima, was opened up by a Company formed for the purpose in 1908. In the following year 2,463 tons of ore were raised, but it was then found that the supply was exhausted, and the mines were closed (**862**, 130).

CENTRAL INDIA AGENCY.

Datia.—NARDHA (26° 13′ : 78° 51′ 30″). A vein of galena in the Par sandstones on the Sind R., a mile and a half above the village of Nardha, is mentioned by Medlicott (**1197**—37, 58). The locality is referred to as 3 miles to the N. N. E. of SEONHRA (26° 9′ : 78° 50′) in the ' Economic Manual ' (**B.** 299). The ore is said to be abundant.

Gwalior.—AINDHAR (25° 33′ : 78° 9′). A deposit of galena at this locality has been examined by Jones (*see* Hayden, **793**—24, 70). The ore occurs in small veinlets and patches, with quartz and barytes, in a band in the gneiss 5 ft. in width. A considerable amount of ore is said to have been proved.

Traces of galena and copper ores have also been found in prospecting trenches at RAGONATHPUR (26° 4′ : 78° 21′), and at a spot 2½ miles to the W. of KARHIA (25° 53′ 30″ : 78° 4′). The amount appears to be small (*see* La Touche, **1034**—39, 113).

Rewah.—URGARHI (24° 14′ : 82° 29′). An old lead mine at this locality is mentioned by Oldham (**1325,** 173). A vein of galena and quartz, about 9 ins. in thickness, is said to have been found at a

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depth of 30 ft. from the surface. On assay the ore yielded 61·6 per cent. of lead, and 7 oz. 16 dwt. 14 grs. of **silver** per ton of lead. The mine is referred to as near the village of BARGAWA (24° 12′ : 82° 31′) in the ' Economic Manual ' (**B.** 298).

CENTRAL PROVINCES.

Bilaspur.—PADAMPUR (21° 45′ : 83° 37′ 30″). Ball (**71**—29, 192) mentions the occurrence of strings and small nests of galena in a bed of Vindhyan limestone exposed in the bed of the Mahanadi R. under the village. The deposit is said to be of no economic importance (**B.** 296).

Drug.—CHICHOLI (21° 4′ : 80° 44′). A discovery of galena in a quartz ridge crossing the main road from Raipur to Nagpur at Ranitalao, 3 miles to the W. of Chicholi, was recorded by Oldham (**1326**—45 ; —56) in 1868. The deposit was afterwards examined by Blanford (**148**—23), who states that the galena, associated with fluor spar, occurs in a well marked quartz vein which was traced for a distance of a mile and a half. The width of the vein was found to vary from 6 to 30 feet. The proportion of galena to vein-stuff appeared to be small. Specimens of the ore yielded 9 oz. 19 dwt. 6 grs. of **silver** per ton of lead (**B.** 296).

An output of 3·25 tons of lead ore from the district is reported in 1914, and of 7 tons in 1915.

Hoshangabad.—JOGA (22° 24′ 30″ : 76° 51′ 30″). Some old excavations at Joga Khurd, known locally as the 'silver mine,' have been described by Nicholls (**1299**, 174). Two parallel series of trenches had been dug along the strike of a band of Bijawar limestone containing apparently irregular veins and nests of galena, which had been followed in places to a depth of 30 ft. The deposit had practically been exhausted, and the samples collected consisted of limestone with scantily disseminated particles of galena. The lead contained **silver** in the proportion of 21 oz. to the ton (**B.** 297).

Jubbulpore.—SLEEMANABAD (23° 38′ 30″ : 80° 19′). The metalliferous lodes at this locality, already mentioned under **COPPER**, contain a certain proportion of galena, which is sometimes very rich in **silver**, picked specimens containing up to 200 ounces. Development work on these lodes has not proved remunerative (**862**, 130).

Nagpur.—NIMA or NIMBHA (21° 24′ : 79° 9′ 30″). The occurrence of fragments of galena on some small hills near the village is

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mentioned by Jenkins (**938**—1, 196) and Hislop (**843**, 380). The source from which they were derived does not appear to have been ascertained (**B.** 298).

Surguja.—BHELAUNDA (23° 52′ : 83° 20′). The discovery of a vein of galena in a hill named Pattia, near the village of Pelawa or Bhelaunda, was reported by Dalton (**410**—2) in 1865. Specimens of the ore are said to have yielded traces of **silver.** An attempt to work the vein proved to be unprofitable (**B.** 294).

CHIRAIKUND (23° 54′ : 82° 54′). An abandoned lead mine, situated about a mile and a half to the S. W. of the village, has been described by Mallet (**1159**—5, 23). The ore occurred in pockets in two bands of horny quartzite interbedded with gneiss. No indications of a true lode were observed (**B.** 295).

MADRAS.

Cuddapah.—JANGAMRAJPILLI (14° 46′ : 78° 57′) or BASWAPUR. The old lead mines in this neighbourhood were first described by Newbold (**1294**—29, 215) in 1842. About 50 pits were then in existence, some of considerable depth. The ore occurs in limestone associated with slates and sandstones, sometimes in cavities lined with quartz and iron oxide, and in other places in veins from an inch to 1½ ins. in width. In 1858 the mines were examined by Wall (**1875**—5, 295), who traced the indications of ore for a distance of 4 miles, but adds little to Newbold's description. According to King (**987**—7, 273), the ore at Jangamrajpilli occurs in quartz veins impregnating limestone belonging to the Cumbum stage of the Cuddapah series, but further to the S. and W. it is found in a granular form in a band of quartzite. The mines appeared to be practically exhausted.

Samples of the ore collected by Wall contained from 66·614 to 69·664 per cent. of lead. A sample assayed by Mallet yielded 78 per cent. of lead, and 22 oz. 7 dwt. of **silver** per ton of lead (**B.** 281).

A description of the native workings has also been given by Gribble in the Cuddapah Manual (**707**—1, 26).

LANKAMALAI (14° 40′ : 78° 58′ 30″). According to Wall (**1875**—3), the metalliferous zone of Jangamrajpilli is continued southwards into the western portion of the Lankamalai hills, E. of Nandialampet. The richest ores occur in a branch vein exposed to the S. E. of the village of NAGASANIPALLI (14° 42′ : 78° 52′). This vein is in two portions, each from 4 to 5 inches wide, and estimated to yield about 18 cwt. of dressed ore per yard. A quartz vein containing galena, which crosses the Pennair R. at KOTELUR (? KOTTUR,

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14° 36′ : 78° 48′), may represent a continuation of the lode to the south (**B.** 284).

Samples from the Nagasanipalli vein yielded from 70·121 to 76·371 per cent. of lead.

Guntur.—KARAMPUDI (16° 26′ : 79° 47′). King (**987**—7, 276) mentions some old lead workings in the N. E. extremity of the Waumyconda range, above Karampudi, among limestones associated with Cumbum slates (**B.** 285).

Kurnool.—BASAVAPURAM or BASWAPUR (15° 24′ 30″ : 78° 41′ 30″). Some old excavations in search of lead ore in this neighbourhood were described by Newbold (**1294**—49, 389) in 1846. The ore occurs in quartz veins traversing slates and schists, and is associated with barytes. Samples collected by Wall (**1875**—4), in the course of prospecting operations, yielded 57·5 per cent. of lead, and 5 oz. 19 dwt. of **silver** per ton of lead. According to King (**987**—7, 273), the ore occurs in joint fissures in slates, as at Jangamrajpilli, striking from N. N. E. to S. S. W. (**B.** 284).

KOILKUNTLA (15° 14′ : 78° 23′). An account of prospecting operations at a spot a quarter of a mile to the S. of the village has been given by Wall (**1875**—4 ; —5, 290). Galena was found disseminated through a hard siliceous matrix occurring as an irregular vein among granitoid rocks. Occasionally large masses of ore were met with. The yield was estimated at about 9 cwt. of dressed ore per fathom. Samples contained from 12 to 14 oz. of **silver** per ton of lead (**B.** 285).

MYSORE.

Chitaldroog.—Foote (**596**—34, 23) mentions the discovery by Mervyn Smith of argentiferous galena at three localities in the neighbourhood of CHITALDROOG (14° 13′ : 76° 27′). Two of these are on the main road to Bangalore, at the 119th and 121st milestones respectively ; and the third on the western slope of Jogi Maradi hill, near the town. Some of the specimens are said to be very rich in **silver.**

Sambasiva Iyer (**1548**—5, 115) has recorded the occurrence of stringers of argentiferous galena on the west slope of a small hill to the S. of KARUBARMARADIKERE (14° 9′ : 76° 29′ 30″), in grits and crystalline limestone. The cleaned ore yielded 72 per cent. of **lead,** and 134·65 oz. of **silver** per ton of lead.

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NORTH-WEST FRONTIER PROVINCE.

Hazara.—Wynne (**1975**—24, 127) mentions the occurrence of a small vein of galena in the KAKAL RAVINE (34° 26′ 30″ : 73° 25′ 30″). Samples yielded on assay 65 per cent. of lead, and 7 oz. 18 dwt. 11 grs. of **silver** per ton of lead. Specimens were also brought by Wynne from UGRI (34° 30′ : 73° 4′) in Agror. Galena is reported to have been found at BANDI MUNIM, near GURINI (33° 55′ : 73° 23′), a few miles from Murree (**B.** 304).

PUNJAB.

Jhelum.—KARANGLI HILL (32° 46′ : 73° 5′). The occurrence of galena, in small nests and detached crystals, near the summit of Karangli hill was recorded in 1848 by Fleming (**591**—1, 517; —3, 675; —5, 256), and has also been noticed by Bowring (**183**—1, 49) and Wynne (**1975**—18, 300). The ore is disseminated through magnesian sandstone forming a precipitous scarp, and can only be reached by means of a rope. It has been mined to a small extent as a substitute for *surma* or antimony.

Fleming (*l. c.*) also mentions a similar occurrence of galena in the gorge above KHEWRA (32° 39′ 30″ : 73° 4′), near a temple on the right hand side of the valley (**B.** 304).

Kangra. } —PARBATI VALLEY. The existence of galena in Kulu
(Kulu) } appears to have been first noticed in 1848 by Parish (**1363**—1, 290), who mentions its occurrence in quartz veins traversing slates at JHARI (32° 0′ : 77° 18′). Hughes (**885**—1, 239) describes the lode as consisting of quartz with strings of galena, pyrites, and arsenopyrite. Its extent was not ascertained. The ore contained from 15 to 20 oz. of **silver** per ton. Massive galena, containing 5 to 6 oz. of **silver**, and 2 to 3 dwt. of **gold**, was also found at SAUGTHAN, 5 miles from Jhari.

In 1865 Mallet (**1159**—1, 165) described an old mine at UCHICH, 2 miles above MANIKARN (32° 2′ : 77° 25′), where the ore is sparingly distributed through quartz filling a narrow vertical fissure. The specimens obtained were not argentiferous (**B.** 307).

Subsequently the district was prospected by Calvert (**265**—2, 72; —3) and by C. and G. Henwood (**823**; **824**—3), when several lodes of argentiferous galena were found in the neighbourhood of Manikarn. The following particulars are given by Calvert :—

KHANOR KHUD.—(1) Lode over 2 ft. in width; ore free from iron and yields 80 oz. of **silver** per ton. (2) Lode apparently several feet thick; the ore and ' gossan ' together yield 61 per cent.

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of lead, 12 dwt. 12 grs. of **gold**, 89 oz. 16 dwt. 16 grs. of **silver**, and 3·8 per cent. of **copper** per ton. (3) Lode several inches thick, yielding 1½ tons of ore per fathom; ore contains 55·5 per cent. of lead, 5 dwt. of **gold**, and 28 oz. 10 dwt. of **silver** per ton.

UCHICH.—Lode over 2 ft. wide; ore yields 29·80 per cent. of lead, 2 dwt. 12 grs. of **gold**, and 22 oz. 2 dwt. 12 grs. of **silver** per ton.

CHONG.—Lode about 6 ins. thick; ore contains 76 per cent. of lead, and 19 oz. of **silver** per ton.

Calvert also mentions a report that a lode of galena 2½ ft. wide occurs at KOMAN, on the eastern side of KOT KANDI (31° 53′ : 77° 16′). The ore is said to contain 56 oz. of **silver** per ton.

(Spiti).—The occurrence of galena in a small quartz vein, infiltrated along a fault plane in upper Triassic limestone between Po (32° 3′ : 78° 23′) and DANKHAR (32° 5′ : 78° 16′), has been noted by Hayden (**793**—9, 102). It is found only in small isolated cubes, which are laboriously extracted and used locally for making bullets.

Simla.—SAR (30° 53′ : 77° 15′ 30″). An old lead mine is said to be situated here, but nothing is known regarding the nature and mode of occurrence of the ore (**B.** 306).

SUBATHU (30° 58′ 30″ : 77° 3′). Lead mines were opened in the year 1869 at CHAPLA, about 2 miles to the N. of Subathu, and at a spot about 2½ miles to the S. E., on the road to Solan. The operations have been described by Kelly (**974**) and Henwood (**824**—2, 471). The ore occurs in the Blaini slates, apparently in lenticular fissures caused by the folding and crushing of the slates. At Chapla the lode was about 2 ft. thick in places, but very irregular. At the other locality there were two lodes 80 ft. apart, one 2 to 3 ft. thick of nearly pure ore, the other varying from 1 ft. 6 ins. to 2 ft. in thickness. Samples assayed at the mine are said to have contained from 68 to 75 per cent. of lead, and 12 to 14 ounces of **silver** per ton of lead (**B.** 304).

Simla Hill States. (Bhajji)—An occurrence of galena at BASANTPUR (31° 12′ 30″ : 77° 14′) has been described by Hayden (**793**—26 76). The deposit, which was situated on the left bank of the Nauti Khad, appeared to have been entirely removed. Fragments of galena and slag were seen in the alluvium of the stream.

(Dargoti).—A deposit of galena, discovered in this State in 1902, was reported by Noetling (*see* Holland, **859**—38, 14), who examined it, to be of no economic value.

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Sirmur.—Herbert (**827**—10, lxxix) has described some lead mines at AIYUR, near the junction of the SUINJ R. with the TONS (30° 46′ : 77° 46′). The locality was visited in 1862 by Medlicott (**1197**—5, 179), who describes the ore as occurring in a well defined lode, about 2 ft. in width, in limestones and slates of the Krol and Infra-Krol groups. A vein of zinc blende, with galena, iron pyrites and quartz, was associated with the lead ore. The ore contained only a small percentage of **silver** (**B.** 306).

RAJPUTANA.

Ajmer.—TARAGARH (26° 26′ 30″ : 74° 41′). Considerable quantities of lead ore were formerly extracted from mines situated at the base of Taragarh hill, close to the city of Ajmer. The native methods of mining, dressing, and smelting the ore were fully described by Dixon (**491**) in 1831. Concentration of the crushed ore was effected simply by throwing it down the slope of the hill. After washing it was kneaded into balls with cowdung and smelted in small clay-built furnaces, each with a capacity of 2 to 3 cwts. of metal daily. According to Hacket (**730**—4, 247), the ore occurs in a number of small roughly parallel veins, penetrating quartzite in nearly the same direction as the strike.

Before the year 1846, when the mines were closed, they produced annually from about 7,000 to 8,500 cwts. of lead, according to a statement in the Ajmer Gazetteer (**1033**, 6). Dixon gives a much lower figure, only 850 cwt. (**B.** 299).

GANESHPURA (26° 1′ : 74° 42′ 30″). Hacket (**730**—4, 248) says that a small quantity of lead ore has been extracted from a pit near the village (**B.** 301).

Alwar.—JODAWAS (27° 21′ 30″ : 76° 22′). An open cutting, from 20 to 30 ft. deep, from which a considerable quantity of lead ore had been extracted, is mentioned by Hacket (**730**—4, 248) ; also a small pocket of lead ore at GUDHA, in the same neighbourhood. The ore from Jodawas is said to contain 80 per cent. of lead, and 1 per cent. of **silver** (**B.** 301).

Mewar (Udaipur).—JAWAR (24° 21′ : 73° 45′).—The mines here are principally noted for their zinc ores, but according to Hardie (**764**—4, 335 ; —7, 70), argentiferous galena also occurs in them. A sample assayed by Tween contained 10 oz. 12 dwt. 8 grs. of **silver** per ton of lead. The mines are said to have been closed at the time of the great famine of 1812-13 (**B.** 301).

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UNITED PROVINCES.

Almora and Garhwal (Kumaon).—Lead ores have been reported to occur at a large number of localities in the Kumaon division, but in most cases the mere fact of its existence is mentioned, and no details are given. Hardwicke in 1799 (**765**, 341) mentions a lead mine in pargana Dasaoli, and Herbert (**827**—10, cxi) notes the occurrence of veins of galena in dolomite on the range between the Sarju and Kosila rivers.

Barratt (**80**—1, 74) mentions lead mines at the following localities:—

RAI (29° 43′ : 80° 5′). The ore occurs in limestone, but no lode is visible.

CHENDAK, 2 miles E. of CHUND, in Goron. Lode 6 to 8 ft. wide, in limestone. Stringers of galena in quartz.

KARAI (?). Nodules of lead ore in limestone.

PATAL, in pargana DEWALGARH (?30° 11′ 30″ : 79° 3′). Lode in quartz, 8 ins. to 2 ft. in width. No ore was seen, but the lode is said to have a very promising appearance.

DHANPUR (30° 13′ : 79° 10′). Lode over 12 ft. in width, consisting of brownish quartz thickly impregnated with galena. The yield is said to be about 6·5 per cent. of metal.

JHAK (30° 9′ 30″ : 79° 26′ 30″). Quartz lode in clay slate with pockets of galena, yielding 33 per cent. of metal with some silver.

Lawder (**1040**—1, 88) mentions lead mines in the GIRTHI VALLEY (30° 40′ : 80° 7′), and at RALAM (30° 18′ 30″ : 80° 20′ 30″), BAINSKAL (29° 55′ 30″ : 80° 13′), TUCHIDA (?), and BAIDLI BAGHIR (?), but gives no particulars (**B.** 308).

A summary of the information available is given by Atkinson (**48**, 31).

Dehra Dun (Jaunsar).—Several old lead mines are situated in the valley of the Tons R., about 25 miles to the N. of KALSI (30° 32′ : 77° 54′), where the ore, according to Medlicott (**1197**—5, 179), occurs under the same conditions as in the adjoining district of Sirmur. The mines at BURAILA (30° 44′ : 77° 51′) and MAIYUR (?) were described in 1829 by Herbert (**827**—6, 256), who says that they were of great extent, but had then ceased to be profitable. The ore at Baraila occurred in limestone, and at Maiyur disseminated in a fine granular form through slate.

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The following localities are mentioned by R. D. Oldham in a manuscript report :—

KUMA (30° 41′ 30″ : 78° 6′). Quartz vein in slates, of which 2 or 3 inches at the base are impregnated with galena and copper pyrites.

KHARSI (30° 45′ 30″ : 78° 2′). Galena in nodules between beds of limestone ; very local in distribution.

KONAIN (30° 47′ 30″ : 77° 57′). Ore occurs as at Kharsi.

MUDHAUL (30° 56′ : 77° 51′ 30″). A galena mine is reported here (**B.** 307).

LIGNITE.

ANDAMAN ISLANDS.

Ball (**71**—11, 236) notes the occurrence of nests of lignite in the Eocene sandstones of Ross and VIPER Is., at Port Blair (11° 41′ : 92° 43′). No continuous seam was found. Analysis :—C=50·8 : Vol.=26·0 : Ash=23·2 per cent. (**B.** 118).

ASSAM.

Abor Hills.—A discovery of ' coal of a superior quality ' reported by Dalton (**407**—2) in the DIRJMU GORGE at the foot of the Abor hills probably refers to lignite, fragments of which are of common occurrence in the Siwalik sandstones. Brown (**211**—5, 236, 252) has also recorded their occurrence between PASIGHAT and JANAK-MUKH (28° 7′ : 95° 17′).

BENGAL.

Darjeeling.—Nests of lignite are frequently found in the upper Tertiary sandstones at the outer edge of the hills. Herbert (**827**—7, 124) noticed their occurrence in the Teesta valley, and a report on specimens from the SIVOK or CHAWA STREAM (26° 53′ : 88° 32′) was drawn up by Oldham (**1326**—5) in 1854. Four specimens analysed by Piddington (**1405**—56 ; —60) gave the following average result :—C=57·56 : Vol.=30·08 : Water=8·20 : Ash=3·97 per cent.

Jalpaiguri.—Deposits of lignite similar to those in the Darjeeling district have been noted by Godwin-Austen (**669**—7), near BAXA FORT (26° 45′ : 89° 38′). A deposit occurring about 2 miles to E. N. E. of JAINTI (26° 42′ : 89° 41′) has been described by Hayden (**793**—3). It consists of sandstone containing isolated logs of lignite, exposed over large areas, but not forming a continuous seam. The lignite contains only a small percentage of ash.

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BOMBAY.

Ratnagiri.—de Crespigny (**450**) has recorded the discovery of beds of lignite at RATNAGIRI (16° 59′ : 73° 21′). The lignite occurs beneath about 37 ft. of laterite, and with the underlying blue clay measures 27 ft. in thickness.

BURMA.

Chindwin (Upper).—Richardson (**1478**—2; —3, 68) and Grant (**692**—1, 149) have noted the occurrence of lignite in large quantities in the banks of the Chindwin R., from 12 to 14 miles above KINDAT (23° 43′ : 94° 28′).

Myitkyina.—Griesbach (**708**—22, 129) states that small quantities of lignite are occasionally brought to Myitkyina from near TALANG (25° 50′ : 97° 29′), a village in the Kachin Hills, 16 miles to the N. N. W. of the Confluence. It is said to occur in a seam from 2 to 3 ft. thick.

Sandoway.—Lignite has from time to time been reported to occur in the Arakan Hill Tracts, but no deposit of value is known to exist. A sample from the neighbourhood of KINGTELLI (KYEINTALI, 18° 0′ : 94° 31′), analysed by Walters (**1880**—4, 264), yielded :—C=33·0 : Vol.=66·4 : Ash=0·6 per cent. (**B.** 113).

Shan States (S.).—A deposit of lignite, situated about 2½ to 3 miles to the S. of THIGYIT (HSIKIP, 20° 24′ 30″ : 96° 46′), has been described by Jones (**952**—4, 190). The lignite occurs in seams 2 or 3 ft. in thickness, and in one case 6 ft., alternating with clay, and has been traced for about a quarter of a mile. It is a lake deposit of recent origin. Analysis :—C=30·22 : Vol.=36·26 : Water=22·74 : Ash=10·78 per cent.

Middlemiss (**1219**—22, 150) has noted the occurrence of similar deposits at two places to the S. W. of NANGÔN (20° 48′ : 96° 45′).

CENTRAL PROVINCES.

Raipur.—Bose (**173**—6) has described an occurrence of lignite in the bed of the Karun R. at BHATAGAON (21° 13′ : 81° 41′), 3 miles to the S. W. of Raipur. The lignite is found in logs with a maximum diameter of 6 ins., imbedded in peaty clay beneath the sand in the bed of the river. Analysis (average of 2 samples) :—C=29·15 : Vol.=48·60 : Water=16·70 : Ash=5·55 per cent.

Similar deposits are said to occur at GHUGWA and JUMRAO, in the same neighbourhood.

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MADRAS.

Malabar and Travancore.—The discovery of beds of lignite on the south-western coast of the Peninsula is due to Cullen (**397**—2) and Newbold (**1294**—17; —33), who described their occurrence at BEPUR (11° 10′ : 75° 52′), CANNANORE (11° 52′ : 75° 25′), and WARKALLI (8° 44′ : 76° 46′) in the year 1840. The lignite occurs in lenticular masses varying in thickness from a few inches to 5 ft. or more, beneath a covering of laterite (**B.** 68).

Further information on the lignite beds of Travancore has recently been supplied by Chacko and Masillamani (**298**, 8, 53, 73). The area occupied by the main mass of Warkalli beds is estimated at 41 square miles, and the quantity of lignite available at 276 million tons.

NEPAL.

Piddington (**1405**—46; —79) has given analyses of two specimens of lignite from Nepal. One of these, from a locality near KATMANDU, contained :—C=25·20 : Vol.=41·50 : Ash=33·30 per cent. The other from ETAUNDA (27° 26′ : 85° 9′ 30″) in the Nepal Terai, contained :—C=50·25 : Vol.=35·50 : Ash=14·25 per cent.

NICOBAR ISLANDS.

Fragments of lignite, occurring under conditions similar to those in the Andaman Islands, were obtained in the Islands of Treis (Teressa), Kondul, and on the south side of the Great Nicobar by Hochstetter (**846**—1, 98) and Rink (**1487**—1, 210). Weathered samples found in the sand of the southern islands were analysed by McClelland (**1117**—30), but there is a possibility that these had been dropped by passing ships. The average results obtained were (3 samples) :—C=40·1 : Vol.=55·8 : Ash=4·1 per cent. (**B.** 119).

PONDICHERRY.

Extensive beds of lignite were met with in the course of artesian boring operations, carried out in the coastal flats between Pondicherry and Cuddalore about the year 1884, and a full description of the occurrence was given by King (**987**—31, 194). At BAHOUR (11° 48′ 30″ : 79° 48′) a bed of lignite 35 ft. thick was passed through at a depth of 275 feet. At ARANGANUR, 2 miles to the N. N. E., two beds of 27 feet and 5½ feet were met with at depths of 203 and 297 feet respectively; and at KONIAKOVIL, 5 miles to the N. E. by N. of Bahour, a bed 50 feet thick at a depth of 330 feet.

Analyses of the mineral quoted by King show very discordant results, the amount of ash varying from about 7 to over 32 per cent.

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A sample analysed by Mallet gave :—C=25·2 : Vol.=29·1 : Water =35·3 : Ash=10·4 per cent. ; but in a briquetted sample the proportion of moisture was reduced to 17·4 per cent., and the quantity of ash increased to 34 per cent. A sample of the natural lignite, analysed by Waddell, gave :—C=37·720 : Vol. =38·551 : Water= 16·276 : Ash=7·451 per cent.

PUNJAB.

Mianwali.—The Jurassic lignite or 'jet coal' of Kalabagh and the neighbourhood has already been noticed under the heading COAL.

Rawalpindi.—In 1868 several deposits of lignite reported to occur in the Murree hills were examined by Davies (**432**). The most promising was found on the east face of NERH HILL (33° 44′ : 73° 36′), but it did not extend for more than 30 feet, with a maximum thickness of 16 inches. The deposits were also examined by H. B. Medlicott (**1197**—15) and J. G. Medlicott (**1199**—4), who pronounced them all to be worthless from an economic point of view.

(Occurrences of lignite in the south-eastern portion of the Punjab Himalaya are noticed below.)

UNITED PROVINCES.

Thin seams of lignite, and scattered logs of carbonised wood, are of common occurrence in the middle or sand-rock stage of the Siwalik group, and have given rise from time to time to reports of the discovery of coal at various localities along the base of the Himalaya between the Sutlej river and the borders of Nepal. The most westerly occurrence noted is in the neighbourhood of KALKA (30° 50′ : 77° 0′), where several outcrops were examined by Griesbach in 1891 (*see* King, **987**—48, 7). The most promising was found in the bed of the Kassaulia stream above TIPRA, but the average thickness of the seam exposed was not more than 2 or 3 inches.

In 1828 Cautley (**292**—1 ; —5, 270) and Herbert (**827**—4) reported the occurrence of thin seams of lignite near SILANI (30° 32′ : 77° 17′) in Sirmur ; at the TIMLI (30° 21′ : 77° 46′), KALAWALA (30° 16′ 30″ : 77° 53′) and other passes leading into the Dehra Dun ; and in the Balia stream below BHIM TAL (29° 21′ : 79° 37′ 30″) ; and discussed the prospects of useful coal being found in these hills. None of the seams found was more than a few inches in thickness. Similar cases have been reported by Ravenshaw (**1462**) to occur in the DHELA R. (29° 25′ : 79° 4′) and other streams issuing from the hills in the northern portion of the Moradabad district.

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Prospecting operations were undertaken in 1901 by Agabeg (**12**) on some lignite seams in the hills between RAJPUR (30° 24′ : 78° 9′) and the Jumna, under the impression that the rocks in which they occur belonged to the Talcher formation. Two seams of 6 and 9 inches in thickness were opened up, but no useful deposit was found.

Deposits of the same character, reported to occur on the Lansdowne road between the first and eighth miles from KOTDWARA (29° 45′ : 78° 36′), were examined in 1906 by Cotter and Brown (*see* Holland, **859**—60, 33). They were found to be mere lenticular patches not exceeding a few inches in length.

Samples of lignite from the Siwalik hills, analysed by Thomson (**1774**—2), contained from 39 to 54 per cent. of carbon, 16 to 48 per cent. of volatile matter, and 4 to 30 per cent. of ash.

LIMESTONE *see under* **BUILDING MATERIALS.**

LITHOGRAPHIC STONE.

No thoroughly efficient substitute for the lithographic stone imported from Germany has yet been found in India, but stone that answers the purpose fairly well has been met with at several places. As Ball remarked (**71**—45, 557), the indigenous stones are difficult to dress and polish; and the fact that they are not used, at least to any appreciable extent, while high prices continue to be paid for European stones, is the strongest argument against their being of any substantial value. The credit of introducing the art of lithography into India has been claimed by Rind (**1486**).

BIHAR AND ORISSA.

Shahabad.—In a paper on the rise and progress of the lithographic art in India, Prinsep (**1436**—3) speaks highly of specimens of Vindhyan limestone from the bed of the Son R. at ROHTASGARH (24° 38′ : 83° 58′); but Stewart (**1703**) says that on trial the stone was found to be too soft and friable for the purpose. These were probably weathered specimens; for Mallet (**1159**—3, 113) quotes a report to the effect that samples sent to Calcutta were very siliceous and too thin for any practical purpose (**B.** 557).

BOMBAY.

Bijapur.—Newbold (**1294**—24, 949) draws attention to a fine grained cream coloured limestone occurring in the Bhima series at TALIKOT (16° 28′ : 76° 22′); and again (**1294**—41, 273) to a pale buff coloured limestone of Kaladgi age at BAGALKOT (16° 11′ : 75°

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46′), as apparently suitable for lithography. Foote (**596**—12, 265) remarks that experiments on the value of these stones, made in Bombay and Madras, had apparently been unsuccessful, as no demand had arisen for them. Similar stone was noticed in the neighbouring district of Shorapur in Hyderabad by Meadows Taylor (**1751**—2, 27), who says that it was used in the Revenue Survey Office for printing village maps (**B.** 559).

CENTRAL INDIA AGENCY.

Rewah.—A sample of Vindhyan limestone, obtained by Shortrede (**1628**) at BARHWA HILL (24° 33′ : 81° 32′ 30″), was favourably reported on by Black (**136**); but the specimen was so small that no definite opinion could be given. The stone was not found *in situ* (**B.** 558).

CENTRAL PROVINCES.

Damoh.—Franklin (**616**—3, 193) mentions the occurrence of thin bedded Vindhyan limestone in the valley of the Sonar R., in the neighbourhood of HATTA (24° 8′ : 79° 40′), which he thinks would be sufficiently compact for lithographic purposes. No trial of the stone appears to have been made.

Raipur.—Serviceable stones are said to have been found in this district, and were being used in 1866 at the Raipur Jail Press (**B.** 558).

HYDERABAD, *see* BOMBAY *above*.

MADRAS.

According to Balfour (**69**—1, 38), the limestones of the Nerji stage in the Kurnool series, which are widely distributed in the districts of Kurnool, Guntur, and Kistna, furnish excellent material for lithographic purposes. The best varieties were obtained from the valley of the TUNGABHADRA R. in Kurnool; from DACHAPILLI (16° 36′ : 79° 48′) in Guntur; and from KONDAPILLI (16° 37′ : 80° 36′) and JAGGAYAPETTA (BATAVOLE, 16° 53′ 30″ : 80° 9′) in the Kistna district. Benza (**110**—4, 45) remarks that limestone similar to that used in lithography occurs at CHINTAPILLI (16° 42′ : 80° 12′) on the Kistna R. (**B.** 557).

PUNJAB.

Mianwali.—Fleming (**591**—5, 265) mentions a yellow argillaceous limestone, probably of Jurassic age, occurring in the Bakh ravine near NAMAL (32° 40′ : 71° 52′), as possibly suitable for lithographic purposes. According to Baden-Powell (**60**—1, Vol. I,

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45), this stone is somewhat soft and not suited for work requiring sharpness of definition (**B.** 559).

RAJPUTANA.

Jaisalmer.—In 1829 a yellow fine grained limestone, occurring at DEORI CHAKARDHA, 5 miles to the N. W. of HUTTU (? HADDA, 27° 25′ : 70° 42′), was recommended by Boileau for trial as a lithographic stone (*see* Prinsep, **1436**—3, 56). A report on this material, with full directions for grinding and polishing the stone, together with a reproduction of a drawing made upon it, was given by R. S. in a subsequent volume of the 'Gleanings in Science' (**1540**). It is stated that the stone is not suitable for fine chalk drawings, but can be used for ordinary purposes with the usual materials (**B.** 558).

UNITED PROVINCES.

Almora.—Herbert (**827**—10, cxiv) mentions the occurrence of a soft argillaceous limestone, resembling lithographic stone, near the village of GÚN (29° 32′ : 80° 13′), on the descent from Pithoragarh to the Sarju R.

MAGNESITE.

BALUCHISTAN.

Jhalawan.—Numerous veins of a white mineral, believed to be magnesite, were found by Vredenburg (**1851**—36, 211) traversing serpentine intrusions to the N. of BANIA PANI, a camping ground 7 or 8 miles to the S. of WAD (27° 20′ : 66° 24′). The network of veins is said to be sometimes so dense as to render the hill slopes entirely white.

BOMBAY.

Idar.—Considerable quantities of magnesite were observed by Middlemiss (**1219**—30, 53) in connection with the steatite deposits occurring near DEV MORI (23° 39′ : 73° 28′), also at KOKAPUR (23° 31′ : 73° 27′).

MADRAS.

Bellary.—Small veins of magnesite were noted by Foote (**596**—39, 136) at the south-eastern end of the SUJI KONDA ridge near DAROJI (15° 15′ 30″ : 76° 43′), traversing hematite quartzites.

Coorg.—Veins of magnesite in peridotites have been found at SERINGALA (12° 22′ 30″ : 75° 34′ 30″), and on the Cauvery R. above FRASERPET (12° 27′ : 76° 1′ 30″), but no details have been published (**862**, 134).

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Kurnool.—Large quantities of magnesite are found in connection with steatite deposits at MADDAVARAM (15° 30′ : 78° 9′), and at MUSILA CHERUVU near BETAMCHERLA (15° 27′ : 78° 13′). The mineral is said to be of inferior quality (**862**, 135).

Salem.—CHALK HILLS (11° 42′ : 78°—11′). The most noteworthy deposits of magnesite in India are those of the 'Chalk hills,' situated between the town of Salem and the foot of the Shevaroy hills. The employment of the mineral in the manufacture of cement was proposed by Macleod in 1825, but the first adequate descriptions of the character of the deposits were given by Benza (**110**—2, 22) in 1836, and by Newbold (**1294**—29, 161) in 1842. Full particulars, including an account of the geological relations of the deposits, were subsequently given by King and Foote (**988**, 312) in their joint memoir on the geology of the district (**B.** 438).

More recently (1895), a detailed survey of this area was carried out by Middlemiss, from whose reports (**1219**—18, 36; —20), and that of King and Foote, the following particulars are taken. The magnesite occurs over an area of about 4½ square miles, forming an intricate network of veins, rarely exceeding 2 or 3 feet in width, and usually much smaller. Owing to their superior resistance to weathering, the veins stand out from the surrounding rocks, giving a peculiar rugged aspect to the surface of the hills. The relative proportion, by volume, of the magnesite to the whole of the rock is estimated by Middlemiss (*l. c.*, 37) as from one-half to one-third over an area of about 130 acres, and from one sixth to one tenth over an area of about 1,140 acres. The remainder of the tract contains only thin veins and patches of magnesite, impossible of estimation.

The intimate association of the magnesite with dunite, an ultrabasic rock of intrusive origin, was noted in 1892 by Holland (**859**—5, 144). Further close study of the petrology of the area led the same observer (**859**—30, 134) to the conclusion that the magnesite originated, not by the conversion of serpentine derived by the ordinary process of hydration from the olivine of the dunite, but independently through the action of carbonic acid upon the olivine, under conditions of high temperature and pressure. The alteration into magnesite is therefore not merely a superficial phenomenon, but may be expected to extend to a considerable depth.

The economic development of the deposits, now carried on by the Magnesite Syndicate, Ltd., founded by H. G. Turner about the year 1900, has been described by an anonymous writer in the *Quarry* (**35**—64), and by Dains (**405**); while Burlton (**234**) has described the employment of the mineral in the manufacture of

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cement. The greater portion of the magnesite quarried in Salem is lightly calcined on the spot, and as 'caustic magnesia' has been shipped to Europe for use as Sorel Cement in the manufacture of artificial stone, floorings, etc.; but its purity renders it eminently suitable for employment as a refractory material in the lining of furnaces. The production of 'dead burned' or 'shrunk' magnesia for this purpose has however practically been abandoned at Salem, owing to the cost of fuel (**862**, 131).

Analyses published by Prinsep (**1436**—23, 510; —28), Gorup Besanez (**683**), and Dains (**405**), show that the mineral consists of 46 to 48 per cent. of magnesia and 50 to 52 per cent. of carbonic acid; with a very small proportion of lime and insoluble matter.

The average annual production of lightly calcined magnesia at Salem, during the five years 1909 to 1913, was 2,159 tons, with a maximum of 4,380 tons in 1913. In 1914 the outturn fell to 399 tons, but a large increase took place in 1915, to 7,450 tons.

KANJAMALAI (11° 37′ : 78° 7′). An occurrence of magnesite in a depression at the N. W. end of Kanjamalai hill was noted by Holland (**859**—5, 142) in 1892. According to Middlemiss (**1219**—18, 37) the area occupied by the dunite, in which the magnesite occurs, is extremely small.

VALAIYAPATTI (11° 7′ 30″ : 78° 17′). This locality is described by King and Foote (**988**, 318) under the name MUTUNAIKKENPATTI, and lies about 3¾ miles to N. by E. of Valaiyapatti. The magnesite is exposed, according to Middlemiss (**1219**—18, 38), over an area of about a mile by half a mile, and is present in extremely small quantity.

King and Foote (**988**, 320) also mention the occurrence of small veins of magnesite along the crest of a low ridge about a mile to the S. of PAVITTIRAM (11° 8′ 30″ : 78° 25′), and in a small valley on the eastern side of ISWARAMALAI (11° 34′ : 78° 28′).

Trichinopoly.—Benza (**110**—2, 22) has recorded the occurrence of magnesite at YEDICHICOLUM (?) near Trichinopoly, and a 'pipe' containing magnesite, the exact locality of which is not given, has been described by Ouchterlony (**1348**—2, 285). A hill lying some miles to the N. W. of MUSIRI (10° 57′ : 78° 30′) is also stated by Muzzy (**1278**, 92) to be partly composed of magnesite and brucite.

King and Foote (**988**, 320 *seq.*) have described occurrences of magnesite, in the form of thin veins in travertine supposed to have been deposited by former springs, at the following localities :—

About a mile to the S. of KAJARIPATTI (11° 11′ 30″ : 78° 30′ 30″).

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Between TIRUPPANGALI (10° 56′ : 78° 42′ 30″) and TIRAMPALAYAM.

About half a mile to the S. E. of VALIKANDAPURAM (11° 19′ : 78° 59′).

MYSORE.

Hassan.—Veins of magnesite up to a foot in width are found, according to Sambasiva Iyer (**1548**—10, 61), in a patch of dunite on the eastern slopes of ENNAHOLE RANGAPPANBETTA (12° 47′ : 76° 20′), a hill situated about 3 miles to the E. of Hole Narsipur.

Mysore.—Deposits of magnesite, occurring at the following localities, have been described by Primrose (**1431**—8, 239 ; —9) :—

MAVINHALLI (12° 13′ : 76° 36′). Four deposits were found in the neighbourhood, of which the largest is situated to the W. of the village, and covers an area of about half a square mile. The magnesite forms a network of veins in a fawn coloured rock associated with hornblende schist and quartzite. The other three deposits lie to the north, and are much smaller in area.

KADUKOLA (12° 11′ : 76° 44′). Magnesite was found at nine places surrounding the village, under the same conditions as at Mavinhalli. The largest deposit lies about 2½ miles to S. S. W. of the village.

A deposit of magnesite, said to be fairly large, occurring on a rise of about a mile to the S. W. of KUPYA (12° 17′ : 76° 53′), is mentioned by Balaji Rao (**68**—1, 100). The same observer has also noted (**68**—5, 152) the occurrence of a small patch of the mineral about three quarters of a mile to the W. of NAGVAL (12° 20′ : 76° 34′).

RAJPUTANA.

Dungarpur.—Daru (*see* Hayden, **793**—31, 27) has reported the occurrence of considerable quantities of magnesite in the western portion of the State, on the same line of exposures as those noted by Middlemiss at Dev Mori and Kokapur, in the neighbouring State of Idar, Bombay Presidency.

MANGANESE.

Among recent advances in the development of the mineral resources of India, none is more striking than that of the manganese industry, which for some years past has disputed with Russia the leadership in the world's production of the mineral, and in most respects holds the first place as regards the quality of the ore. The

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industry dates from the year 1891, when a Company was formed for the purpose of opening up the deposits of the Vizagapatam district in the Madras Presidency. Before that year the literature of the subject was confined for the most part to casual references to isolated occurrences of the mineral in various parts of the country, with the single exception of the ores of Gosalpur and Sihora in the Jubbulpore district, which received much attention between the years 1880 and 1890; though it has now been ascertained that the economic value of these ores, in comparison with that of the rich deposits in other parts of the Central Provinces whose existence was then not even suspected, is of little practical importance. It was not until the industry had been established for many years in a sound and flourishing condition that the subject was adequately dealt with by the Geological Survey; but this reproach was removed in 1909 by the publication of Dr. Fermor's exhaustive memoir (**577**—32), of which Part I discusses the mineralogy, Part II the geology, mode of occurrence and origin, Part III the economic development and exploitation, and Part IV the distribution in the field, of the manganese ores of India.

In addition to this work, from which the notes given below are mainly taken, information of a general character is supplied by the following writers :—

1881. Ball (**71**—45, 326-332). Summary of previous information.

1906. Fermor (**577**—14). Describes briefly the mode of occurrence, origin, and distribution of the manganese ores, with remarks on the prospects of the industry.

1906. Holland (**859**—56, 94). A summary of Fermor's investigations.

1906, 1908. Venator (**1836**—1; —2). Essays on the demand for and valuation of manganese ores, and on their production and consumption by various countries.

1907. Ghose (**652**—1). Compares the Indian manganese industry with that of Russia, Brazil, etc., with a brief account of the Indian deposits.

1907. Martell (**1178**). Describes the mode of occurrence of the Indian deposits.

1913. Hänig (**756**). An account of the manganese deposits of British India.

The economic aspect of the industry, especially the composition and valuation of the ores exported, are fully discussed in the Quinquennial Reviews of Mineral Production (**859**—50, 55; **861**, 128; **862**, 135).

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In accordance with their geological relations and mode of origin, the manganese ores of India are classified as :—

(*a*) Ores associated with the 'kodurite' series of Ganjam and Vizagapatam. The kodurites are a group of intrusive igneous rocks (possibly hybrids, *see* p. 352) consisting typically of manganese garnet (spandite), orthoclase felspar, and apatite in varying proportions. From these the manganese ores have been developed by secondary changes brought about by the percolation of aqueous solutions charged with carbonic acid and alkaline carbonates, resulting in the concentration of the manganese into ore bodies, accompanied by the formation of lithomarge, chert, and opal. The depth to which the ores extend is therefore probably determined by that of the zone of weathering in past times.

(*b*) Ores occurring in the Dharwar rocks, either as consolidated beds of chemically deposited manganese oxide, or associated with the 'gondite' series, a group of highly metamorphosed manganese—silicate-rocks resulting from the alteration of the less pure manganiferous sediments. From these the ore bodies have been formed by subsequent oxy-alteration at considerable depths. It is believed that this alteration took place in late Archæan times, and it follows that the ores may be expected to extend in places to as great a depth as the rocks of the gondite series (Fermor, **577**—36, 9). Occasionally the ores are associated with crystalline limestone. The gondite ores are typically developed in the Central Provinces.

(*c*) Lateritoid ores, occurring in places on the outcrop of the Dharwar rocks, and formed by the surface replacement of the constituents of these rocks by manganese introduced in solution by percolating waters, sometimes with subsequent segregation.

(*d*) Ores occurring in true laterites, as in Goa. These are probably formed by segregation during the formation of the laterite.

In addition to these main groups, manganese ore is occasionally found in rocks of various ages, from Purana (Bijawar, etc.) to Recent; but in none of these cases is the ore of any commercial value.

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As regards the classification of the ores for commercial purposes, the following scheme is proposed by Fermor (577—32, 500) :—

Class.	Designation.	Mn per cent.	Fe per cent.
I	Manganese ores	40—63	0—10
II	Ferruginous manganese ores	25—50	10—30
III	Manganiferous iron ores	5—30	30—65
IV	Iron ores	0—5	45—70

The following table of mean analyses of the different classes of ore is condensed from that given by Fermor (577—32, 512-513) :—

Province or District.		Class.	No. of Analyses.	Mn per cent.	Fe per cent.	SiO_2 per cent.	P per cent.	H_2O per cent.
KODURITIC ores.	Ganjam . . .	II	1	28·44	19·70	10·25	0·71	2·55
	Vizagapatam	I	8	44·34	9·08	4·15	0·32	..
		II	19	40·67	12·68	4·77	0·29	0·90
GONDITIC ores.	Central Provinces.	I	64	51·83	6·80	5·99	0·120	0·42
	Gangpur (Fermor 577—37, 15).	I	5	49·31	6·59	4·41	0·117	..
		II	1	45·48	16·33	0·65	0·141	..
	Jhabua . .	I	5	46·94	8·44	8·14	0·20	0·43
LATERITIC ores (in laterite and laterite).	Belgaum	II	10	44·77	10·33	1·40	0·035	..
		III	2	10·53	49·55	2·27	0·023	..
	Dharwar .	II	10	31·62	16·8	19·1	..	..
	Panch Mahals .	I	4	41·68	4·07	19·11	0·20	0·35
	Satara . .	I	4	40·79	6·94	3·75	0·07	1·99
	Jubbulpore	I	3	45·56	4·79	2·68	0·215	0·56
		III	7	20·26	28·78	12·99	0·25	0·37
		IV	4	0·96	50·50	10·76	0·32	0·33
	Sandur . .	II	6	47·75	11·45	0·61	0·030	..
	Shimoga .	I	9	49·10	7·74	2·62	0·085	..
		II	3	46·75	10·06	1·77	0·031	0·95

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The production of manganese ore in India increased steadily from 674 tons in 1892 (at the Kodur mines, Vizagapatam) to a maximum of 902,291 tons in 1907. During the five years 1909 to 1913, the average annual output was 712,797 tons. In 1914 the production amounted to 682,898 tons; in 1915, owing to abnormal conditions, it fell to 450,416 tons, but in 1916 it rose again to 645,204 tons.

N. B.—References to Fermor's memoir on the manganese ores of India (**577**—32) are denoted below by the letter **F.**

ANDAMAN ISLANDS.

BALMI CREEK (13° 3′: 92° 53′), in North Andaman I. Nests of manganese were found in quartzite of pre-Tertiary age by Tipper. They are of no economic value (**F.** 613).

BALUCHISTAN.

Jhalawan.—Fifteen tons of manganese ore were raised during 1907 from a deposit at the foot of the PAB HILLS, about 70 miles from Karachi.

Fragments of psilomelane were picked up by Tipper (**1787**—5, 215) near the SHEKRAN lead mines (27° 53′: 66° 28′). The ore probably formed part of the gangue of the lead ores (**F.** 613).

BENGAL.

Burdwan.—Piddington (**1405**—1, 173) gives analyses of iron ores from several localities not shown on the map. Two of these, from MALCHAITI and PAOLTA KANOWA, are manganiferous ores containing 16 and 10·25 per cent. of manganese oxide respectively (**F.** 614).

24-Parganas.—On the beach near SILVER TREE G. T. S. (21° 58′: 88° 12′), numerous small pisolites of manganese ore are reported by T. Munro to occur just above high water mark. The origin of the nodules is not known (**F.** 631).

BIHAR AND ORISSA.

Gangpur.—GARIAJHOR (22° 3′: 84° 12′). Discovered by Schrager in 1907, and described by Fermor (**577**—37). Outcrops of manganese ore occur in a band of gondite rocks extending from KENDMAL, S. W. of Gariajhor, to KUSUMMUNDA, about 3½ miles to the N. E. The most important ore body forms the crest of Gariajhor hill, and is about 720 feet in length by 10 to 20 feet thick. Range of analyses:—Mn=45·48—58·64: Fe=1·70—16·33: SiO_2=

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0·65—11·20 : P=0·08—0·15 per cent. Average annual production, 1909 to 1913, 32,112 tons. In 1914, the output was 6,070 tons; in 1915 nil; and in 1916 2,832 tons.

Hazaribagh.—In 1850 Piddington (**1405**—38) described a variety of manganese garnet from KATKAMSANDI (24° 7′ : 85° 16′), to which he gave the name 'calderite.' On analysis the mineral yielded 21 per cent. of manganous oxide. Specimens of garnet from SIRSIA (24° 22′ : 86° 17′) also give a strong manganese reaction (**F.** 182, 615).

Kalahandi.—OLATURA (20° 20′ : 83° 35′). Manganese ore containing 41·03 per cent. Mn was found by Walker (**1872**—3, 20) with iron ores on a hill near the village (**F.** 616).

Manbhum.—The iron ores from the Ironstone shales of the Raniganj coal field, used by the Barakar Iron and Steel Company, contain a small percentage of manganese, ranging from 1·4 to 2·5 per cent. (**F.** 614).

Mayurbhanj.—Traces of manganese ore have been found by Bose (**173**—20, 170) near KULIANA, about 8 miles to the N. of BARIPADA (21° 56′ : 86° 47′). The ore occurred in laterite, close to an outcrop of banded blackish quartzite (**F.** 617).

Monghyr.—KATNOWA HILLS (24° 57′ : 86° 20′). Loose blocks of manganese ore are reported to occur at the foot of these hills and in the hill itself. A sample yielded on analysis 28·26 per cent. Mn with a little baryta. The quantity available is said to be small (**F.** 617).

Singhbhum.—CHAIBASA (22° 33′ : 85° 52′). Ball (**71**—46, 146) has recorded the occurrence of manganiferous hematite and limonite in a ridge to the S. of the town. The ores are of a lateritic character developed on the outcrop of Dharwar phyllites, sandstones, quartzites and grits. Deposits have been located at the following places in this neighbourhood :—

BISTAMPUR or MATAGOTA (22° 27′ : 85° 51′). Ore occurs in a group of hills a quarter to half a mile to W. N. W. Area of largest deposit about $1\frac{1}{3}$ acres; in places 2 feet thick. Analysis :—Mn=46·89 : Fe=1·37 : SiO_2=3·15 : P=0·27 per cent. (**F.** 629).

GITILPI (22° 31′ : 85° 52′). Psilomelane occurs in thin layers associated with limonite. Analysis :—Mn=48·01 : Fe=6·10 : SiO_2=2·45 : P=0·35 per cent. (**F.** 626).

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KALENDA (22° 29′ : 85° 52′). Psilomelane occurs with limonite. Said to be about a foot thick (**F.** 628).

LAGIA (22° 32′ : 85° 46′). Ball (**71**—46, 147) mentions the occurrence of iron ore rich in manganese.

MATKAMHATU (22° 32′ : 85° 51′). Manganiferous limonite, portions of which contain 21 per cent. Mn, occur in a group of hillocks half a mile to E. S. E. of the road to Chaibasa. The highly manganiferous portion of the deposit is about 70 paces in length and 50 feet wide (**F.** 623).

TEKRASAI (22° 31′ : 85° 52′). Layers of psilomelane ¼ to 1 inch thick, forming a nearly horizontal bed of ore from 15 to 21 inches in thickness. Covers only a small area. Analysis (picked sample) :— Mn=48·08 : Fe=1·22 : SiO_2=8·30 : P=0·42 per cent. (**F.** 625).

TUTUGUTU (22° 29′ : 85° 50′). Deposit situated about 1¼ mile to S. of village. Slates and phyllites with intercalated layers of psilomelane from ½ inch to 6 inches thick. About 1,000 tons of ore were extracted during 1907 (**F.** 628).

LEDA HILL (22° 28′ : 85° 26′). Discovered by Saubolle in 1907. The ore occurs at the crest of the hill, which is about half a mile in length, mixed with iron ores and containing residual patches of quartzite or slate. No large quantity is available at any one spot (**F.** 630).

During the years 1906 and 1907, 2,933 tons of ore were raised from the Gitilpi, Kalenda, and Tutugutu deposits. An output of 507 tons of ore from the district was recorded in 1915, and only 2 tons in 1916.

BOMBAY.

Belgaum.—BHIMGAD (15° 35′ : 74° 21′). Foote (**596**—12, 56, 259) records the occurrence of dark brown earthy wad, containing 20 per cent. of manganese peroxide, as a product of weathering on the surface of dolomite near the east gate of the fort (**F.** 634).

MANIKEHRI (16° 10′ : 75° 8′). A vein of manganese ore, about 3 inches in width, was observed by Newbold (**1294**—41, 275) in Kaladgi quartzite (**F.** 633).

NAGARGALI (15° 24′ : 74° 41′). Nodules of manganese ore in laterite are reported by Maclaren to occur here (**F.** 642).

NERSA (15° 35′ : 74° 30′). Thin bands of manganese ore occur in soft decomposed Dharwar schist. Forty tons of ore were extracted in 1905 (**F.** 639).

TALEVADI (15° 33′ : 74° 22′). Discovered by T. B. Kantharia in 1904. Concretions of psilomelane with some pyrolusite and wad are irregularly distributed through laterite resting on Dharwar

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schists and slightly manganiferous limestone. The concretions sometimes measure 3 feet in diameter but decrease in size and hardness with depth. At one spot the ore was compacted into a mass covering about 180 square yards, and 8 feet thick. Range of analyses (14 samples):—Mn=8·23—60·85: Fe=51·88—0·10: SiO_2=0·65—2·70: P=0·011—0·119 per cent. (**F.** 635).

During the years 1905 to 1908, 2,778 tons of ore were raised from this deposit and despatched to Mormugao.

The origin of the laterite at this locality, and of the ores accompanying it, has been discussed by Maclaren (**1134**—5, 538).

TAWARGATTI (15° 25′: 74° 44′ 30″). Small quantities of psilomelane and pyrolusite occur as nests and linings to cracks in quartzite, about a mile to the E. of the railway station (**F.** 642).

Bijapur.—BAGALKOT (16° 11′: 75° 46′). According to Aytoun (**51**—2, 33, 46, 49, 54, 57), fragments of manganese ore are scattered in considerable abundance on the surface between Bagalkot and Kaladgi, and in a valley on the further side of a range of low hills S. of Bagalkot. Veins of manganese ore were also seen in limestone near the town. On the other hand, Foote (**596**—12, 31) says that he observed pyrolusite and psilomelane in this neighbourhood only in very small quantities (**F.** 640).

INGLESWARA (16° 39′: 76° 5′). Newbold (**1294**—32, 1002) mentions the occurrence of veins of manganese in laterite, and of nodules containing cavities filled with impure earthy manganese, among the debris at the foot of laterite cliffs S. W. of the village (**F.** 640).

Dharwar. } —CHIK VADVATI (15° 10′: 75° 47′) and KELUR (15°
(Sangli) } 9′: 75° 50′). In 1840 Newbold (**1294**—15, 44) reported the discovery on the Kappadgod range, about 2 miles to the E. of 'Chick Wodoorti,' of a black mineral which was identified by Braddock (**186**—2, 51) as manganese ore. The occurrence was afterwards described in greater detail by Newbold (**1294**—29, 212). The ore occurs in masses of considerable size over a wide area. Recent prospecting work has shown (*see* Maclaren, **1134**—4, 128; Ahlers, **16**—1, 451) that the ore is developed on the outcrop of hematite quartzites of Dharwar age, and that it is too irregular in distribution and variable in quality to be of economic value. Range of analyses (10 samples):—Mn=19·45—38·48: Fe=13·3—25·3: SiO_2=7—31 per cent. (**F.** 644).

Similar deposits occur further to the south near HAMIGI (15° 3′: 75° 54′).

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SHIRHATTI (15° 14′ : 75° 38′ 30″). Fragments of manganese ore are said to have been found on the fields to the S. W. of the village (**F.** 646).

North Kanara.—SUPA (15° 16′ : 74° 34′ 30″). Lateritoid ores have been found over a wide area to the N. and N. E. of the village, resting on the outcrop of banded hematite quartzites of the Dharwar series. The ores are not concentrated in workable quantity at any one spot. The quality is very variable, but the percentage of silica and phosphorus is uniformly low (**F.** 649).

Palanpur.—ROHU (24° 24′ : 72° 42′). Some brownish jaspery quartzite with secondary psilomelane was found by Baidyanath Saha at a spot 2 miles to the N. of the railway station. Manganese garnet was also found at HOSHANPUR (24° 16′ : 72° 36′)—(**F.** 650).

Panch Mahals.—SIVARAJPUR (22° 25′ 30″ : 73° 40′). The existence of manganese associated with magnetic iron ore in this neighbourhood was reported by Blanford (**148**—22, 341) in 1869. Development work has proved the existence of ore bodies of considerable size, distributed along the crest of a ridge to the S. E. of the village for a distance of about 3 miles. The ores consist of psilomelane with some braunite, and pyrolusite, formed mainly by replacement of limonite quartzites of the Champaner (=Dharwar) series; but some compacted manganiferous sediments may also be present. The deposits have been worked since 1905 by the Shivrajpur Syndicate, Ltd., and an adjoining deposit on Bamankua Hill since 1907 by the Bamankua Manganese Co., Ltd. Range of analyses (4 samples) :—Mn=30·20—49·35 : Fe=3·05—6·25 : SiO_2=2·80—40·65 : P=0·16—0·25 : H_2O=0·30—0·40 per cent. (**F.** 651).

The average annual production of manganese-ore in this district during the 11 years 1906 to 1916 was 29,257 tons, the output in 1916,—66,160 tons—being the highest recorded.

Ratnagiri.—Aytoun (**51**—3, 82) has recorded an occurrence of thick veins of manganese ore in laterite at RAIRI (REDI, 15° 45′ : 73° 43′) Point. An output of 525 tons from the district was recorded in 1910.

Rewa Kantha. (Chota Udaipur)—An output of 7,735 tons of manganese ore from Chota Udaipur is recorded in the returns of mineral production for 1914 (**793**—33, 171). No description of the deposit has been published, but it is said to be situated near the village of PANI (22° 29′ : 73° 51′).

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(**Narukot**).—JOTHVAD (22° 23′ : 73° 47′). The mode of occurrence of manganese ore here is cited by Fermor (**577**—36, 4) as an indication that the alteration of the manganese silicates of the Dharwar series took place in Archæan times. A small hill situated half a mile to the N. of the village consists of banded gneisses, including several varieties of gondite and manganiferous limestones. These rocks are penetrated by intrusions of Archæan granite, enclosing fragments of the manganese silicates and manganese ore, which were presumably in existence at the time of the intrusion. The ores are of no economic value (**F.** 646).

(**Rajpipla**).—The iron slags already noted under the heading IRON, in the neighbourhood of LIMODRA (21° 44′ : 73° 12′ 30″), are said to contain traces of manganese (**F.** 661).

Satara.—At a number of localities on the basaltic plateaus of Mahableshwar and Yeruli, concretionary nodules of psilomelane are found in some abundance scattered through clayey soil resting immediately upon decomposed trap rocks. The nodules usually occur near the base of laterite cappings, but have not been found in the laterite itself. They have probably been formed in the soil by the accretion of particles of manganese oxide derived from the trap. The quantity as yet observed at any one place is not sufficient to warrant exploitation. Range of analyses (4 samples) :— Mn=37·58—45·62 : Fe=4·40—9·25 : SiO_2=2·90—4·75 : P=0·036—0·098 : H_2O=1·70—2·50 per cent. (**F.** 661).

Deposits have been found at the following localities :—

AWKALI, BHEKAULI, CHIKHLI, LINGMALA, MALUSAR, METGOTAR, SINDOLA, TEKOWLI — All in the neighbourhood of MAHABLESHWAR (17° 56′ : 73° 43′).

KAS (17° 43′ : 73° 52′).

KHANAPUR (17° 15′ : 74° 47′).

WAI (17° 57′ : 73° 57′), on the Yeruli plateau.

BURMA.

Amherst.—O'Riley (**1340**—3, 733) says that he found grey oxide of manganese in the 'secondary' formation' on the THAUNGYIN

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and GYAING rivers. Its occurrence in the district has also been reported by Mr. H. Thompson (**F.** 669).

Insein.—According to Romanis (**1511**—4), the surface soil at ENGSEIN (INSEIN, 16° 53′ : 96° 8′) contains nodules and bands of manganiferous iron ore (**F.** 669).

Magwe.—Romanis (**1511**—8, 2) has reported the occurrence of concretions of manganese oxide in the neighbourhood of YENANG-YAUNG (20° 28′ : 94° 54′), probably in the 'Fossil Wood' group (**F.** 669).

Mergui.—A black mineral occurring in considerable quantities on the THAGU and THERABWIN streams, tributaries of the Gt. Tenasserim R., and described by Tremenheere (**1802**—3) as wad, was shown by Piddington (**1405**—24) to be a carbonaceous substance containing no manganese.

Manganese ore is reported by Mason (**1185**—1, 48) and Anderson (*see* Mallet, **1159**—50, 61) to occur on some of the islands of the Mergui Archipelago, especially on GNA ISLET, PADAU BAY, KING I. (12° 29′ : 98° 25′).

Specimens of tin stone collected by Hughes (*see Records, G. S. I.*, XXIV, 135) at KUMONG, near MALIWUN (10° 14′ : 98° 39′) were found on assay to contain a large proportion of manganese, present in admixed wolfram (**F.** 669).

Myingyan.—At the extreme north end of the Kabat anticlinal, near SEIKTEIN (21° 3′ : 95° 19′), Pascoe (**1369**—1, 248) noted the occurrence of blocks of a detrital limestone, consisting largely of bryozoan and foraminiferal tests, the material of which has been replaced by brown oxide of manganese (**F.** 670).

Sagaing.—Prinsep (**1436**—10, 15) has described a specimen of black oxide of manganese, forwarded by Major Burney from Ava. The locality is not mentioned (**F.** 671).

Salween.—Wad was observed by Romanis (*see* Mallet, **1159**—50, 62) as a thin film coating the rocks near Yetagon, a few miles above Yinbaing (17° 24′ : 97° 49′) on the Salween (**F.** 671).

Toungoo.—According to Theobald (**1763**—16, 267), the nodular iron ore characteristic of the uppermost bed of the 'Fossil Wood' group in eastern Prome is represented in Toungoo by tabular

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masses and irregular nodules of manganese ore, on the low range of hills dividing the Yayuay and Seing Kyaung from the Sittang R. A sample analysed by Tween yielded 28 per cent. of manganese oxide (**F.** 671).

CENTRAL INDIA AGENCY.

Bhopal.—KANUGAON (23° 15′ 30″ : 77° 26′). Irregular nodules of psilomelane, up to 6 inches in diameter, apparently weathered out from Vindhyan sandstones, occur in the lower layers of the surface soil. The quantity observed is small (**F.** 672).

Dhar (Nimanpur).—The manganese ores of this area are found replacing the matrix of a peculiar breccia, resulting, it is supposed, from the lateritisation of the superficial Bijawar rocks before the deposition of the overlying Lameta (lower Cretaceous) formation. The following occurrences, none of which appears to be of economic importance, have been noted (**F.** 672-676) :—

KANAR (22° 28′ : 76° 12′), E. side of hill 925 feet. Small deposit consisting of patches of pyrolusite in quartzite breccia, not exceeding 2 feet in thickness.

KATOTIA (22° 24′ 30″ : 76° 22′). Manganiferous and ferruginous sandstone with a calcitic cement.

KHERIA KUND (22° 29′ : 76° 22′). Mixed wad and ochre, occurring in a tributary of the Ghorapachar R., to the N. of the village.

PAN KUAN (22° 32′ : 76° 22′). Bijawar limestone coated with pyrolusite to a depth of 2 to 3 inches.

POLA KHAL (22° 28′ : 76′ 20′). Concretionary psilomelane forming the matrix of Lameta conglomerate. Analysis :—Mn= 20·29 : Fe=3·65 : P=0·016 per cent.

RATAGARH (22° 25′ : 76° 17′). A single boulder consisting probably of hollandite.

W. S. W. of hill 888 feet (22° 27′ : 76° 20′). Calcareous wad, probably replacing Bijawar limestone.

Dholpur.—A supposed occurrence of manganese ore at KESARBAGH (?) was found on investigation by Heron (*see* Hayden, **793**—31, 21) to be of no economic value. The manganese is deposited in the form of thin plates along joint planes.

Gwalior.—Some impure psilomelane has been found by K. D. Kulkarni on a hill situated a quarter of a mile to the S. of BEHAT (26° 10′ : 78° 36′), in the Gwalior (=Bijawar) series. Mallet (**1159**

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—50, 59) also records the receipt of specimens of manganite from the State (**F.** 676).

Indore.—Manganese ore occurs under the same conditions as in the Dhar Forest at the following places (**F.** 676) :—

BAREL (22° 23′ : 76° 7′). In a band of siliceous Bijawar breccia.

BHAMAR (22° 21′ : 76° 43′). Black impregnations in breccia associated with Bijawar rocks.

KANAR R. (22° 26′ : 76° 13′). Wad forming the matrix of siliceous breccia. The same mineral also occurs in breccia and in Lameta grits, in a small tributary of the Kanar R., about 3 miles to the N. E. of KATKUT (22° 25′ : 76° 10′).

Jhabua.—KAJLIDONGRI (22° 57′ : 74° 32′). The ores here are associated with sericitoid phyllites, gondite rocks, and quartzites belonging to the Aravalli series. They form a bed about 20 feet thick, kept at the surface by a series of folds in such a manner that the apparent thickness of the ore body reaches about 250 feet. The outcrop extends for a length of about 1,000 yards. The deposit is of a complex character, the northern portion consisting largely of braunite resulting from the alteration of the gondite, while the southern portion is a fine grained mixture of psilomelane and braunite, partly representing original manganiferous sediments, and partly due to the replacement of the quartzites by manganese-oxide. Range of analyses :—Northern portion, Mn=46—52 ; Fe=8—9 : SiO_2=7—11 : P=0·15—0·30 per cent. Southern portion, Mn=46—48 : Fe=8—9 : SiO_2=6—9 : P=0·08—0·25 per cent. Both varieties contain a small percentage of baryta (**F.** 679).

This deposit produced 190,519 tons of ore between the years 1903 and 1913 inclusive. Since the year 1910 the output has declined. In 1914 it was 6,642 tons, and in 1915 it fell to 366 tons, whilst no production was recorded for 1916.

RAMBHAPUR (22° 55′ : 74° 33′). The existence of an outcrop of manganese ore at Piploda, half way between Kajlidongri and Rambhapur, indicates that these deposits are genetically connected. That at Rambhapur is composed of alternate layers of ore and red quartzite, forming a bed probably 10 feet thick, repeated by folding. Length of outcrop about 250 yards. Average analysis (2 samples) :—Mn=45·10 : Fe=6·88 : SiO_2=8·55 : P=0·175 per cent. (**F.** 687).

Manganese ore has also been observed by H. Walker (*see* Holland, **859**—66, 47) at :—

AMLAMAL (23° 0° : 74° 28′ ,30″). A thin lode in fine grained spessartite-quartz rock.

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PITOL (22° 47′ : 74° 31′ 30″). Low grade ore, interlaminated with quartz, occurs in a mound about a mile to the S. E. of the village.

TUMDIA (22° 45′ : 74° 32′). A small outcrop of white quartzite, 2 to 3 feet in width, containing veins and lenticles of manganese ore. Boulders of a similar rock were seen between Nagankheri and Mandli, close to Tumdia (**F.** 689).

CENTRAL PROVINCES.

Balaghat.—The manganese deposits are confined to a belt of country about 75 miles in length, and 9 miles in width, stretching across the central portion of the district from W. S. W. to E. N. E. In that portion of the belt which lies to the east of the Wainganga R., the ores occur near the base of the Chilpi Ghat series, a group of slaty and schistose rocks probably representing the Dharwars, but comparatively free from the intense metamorphism which has affected this system in other areas. To the west of the river the ores occur among more highly metamorphosed rocks, with which are sometimes associated calcareous gneisses; the former were considered by Fermor to represent a more highly altered facies of the Chilpi Ghat series; but it is possible, as Burton has shown (*see* Middlemiss, **1219**—31, 131), that the whole of these rocks belong to an older group of altered sedimentaries, called by him the Sonawani series.

Proceeding from west to east, ore deposits have been noted at the following localities:—

I. West of the Wainganga:—

CHANDADOH (21° 42′ : 79° 44′). A band of quartzose gondite, with a little soft black manganese ore, exposed about three quarters of a mile to the E. of the village (**F.** 698).

THIRORI (21° 41′ : 79° 47′). Five parallel ore bands are exposed in places, but usually from one to three only, over a total length of outcrop of 6 miles, between the villages of Jamrapani and Ponia. The bands are due to the repeated folding of a single bed of ore. Much of the ore is of high grade, consisting of a hard grey mixture of psilomelane and braunite, and 'speckled ore,' a lead-like variety of psilomelane containing cavities filled with black powdery ore. The deposit produced 218,040 tons of ore, from 1902 to 1913 inclusive. Analysis (average of 6 samples):— Mn=52·29: Fe=7·77: SiO_2=3·86: P=0·11: H_2O=0·38 per cent. (**F.** 698).

SONEGAON (21° 41′ : 79° 50′ 30″). Interbanded grey quartzite and gondite with a little manganese ore, exposed about a quarter of a mile to S. W. of the village (**F.** 706).

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ARJONI (21° 46′ : 79° 57′ 30″)—JAM (21° 46′ : 79° 56′). Outcrop about half a mile in length, consisting of interbanded quartzite and gondite, with patches of ore of doubtful economic value (**F.** 706).

NANDGAON (21° 49′ : 79° 58′ 30″). An obscure outcrop of gondite and manganese ore, half a mile to W. 15° S. of the village (**F.** 708).

RAMRAMA (21° 51′ : 79° 59′). Outcrop about three-eighths of a mile in length, forming a low ridge about a mile to N. E. of the village. One or two ore bands are exposed, consisting mainly of good quality ore. Analysis :—Mn=52·78 : Fe=7·83 : SiO_2=5·35 : P=0·09 : H_2O=0·22 per cent. (**F.** 708).

KATANGJHERI (21° 50′ : 80° 2′) (*a*), (Shodan Hurki) about 2¼ miles to N. N. W. of village. Outcrop about 500 yards in length. Hard grey ore interbanded with quartzite, passing into soft ore poor in quality towards the east. Analysis :—Mn=53·96 : Fe=5·97 : SiO_2 =6·02 : P=0·04 : H_2O=0·23 per cent. (**F.** 710).

(*b*) About a mile to W. 15° N. of village. Outcrop nearly half a mile in length, consisting of quartzite with bands of spessartite rock partly altered to ore. The only workable portion, near the N. W. end of the outcrop, consists of 'speckled ore.' Analysis :—Mn=49·08 : Fe=6·63 : SiO_2=1·62 : P=0·11 : H_2O=0·85 per cent. (**F.** 711).

BHUI HURKI (21° 52′ : 80° 2′). Ridge composed of spessartite-bearing rock, half a mile to E. of village (**F.** 713).

BALLARPUR (21° 54′ : 80° 6′).
BAKODA (21° 55′ : 80° 7′). } Ore said to have been found *in situ*.
BOTAJHARI (21° 49′ : 80° 0′).

CHAUKHANDI (21° 43′ 30″ : 79° 50′).
CHIKMARA (21° 44′ : 79° 51′).
SIRPUR (21° 47′ 30″ : 79° 57′).
KOCHAWAHI (21° 48′ : 80° 0′). } Fragmentary ore.
BUDBUDA (21° 47′ 30″ : 80° 2′).
SAONRI (21° 41′ : 79° 52′).
NANDHI (21° 41′ : 79° 53′).

A palæolithic implement made of manganese ore, found near Budbuda, has been described by Fermor (**577**—35).

The following additional localities have been recorded by Burton (*see* Middlemiss, **1219**—31, 115) :—

GOLA HURKI (?). Band 15 feet thick.
NETRA (21° 51′ : 80° 4′). Band 16 feet thick.
BIAHTEKOR (21° 54′ : 80° 5′).
CHIBARGHAT STREAM (21° 48′ : 80° 1′).

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II. East of the Wainganga.

BALAGHAT (21° 48′ : 80° 15′). The deposit is situated about 2½ miles to the N. E. of the town of Balaghat, on a spur from the Baihar plateau. The total length of the ore band is 1¾ mile, and the maximum thickness about 45 feet. It consists in part of dull grey psilomelane, sometimes containing cavities filled with black powder, and in part of light-grey crystalline hollandite, and is interbanded with red and black quartzite often replaced by manganese ore. The deposit has been worked since the year 1901, and has produced, to the end of 1913, 725,248 tons of high grade ore. Analysis :—Mn=52·63 : Fe=5·28 : SiO_2=2·62 : P=0·05 : H_2O=0·12 per cent. (**F.** 714).

LAUGUR (21° 56′ : 80° 25′). Ore band about 2,000 yards in length, and 2½ to 6 feet in width, about half of which is waste (**F.** 726).

GHONDI (21° 56′ : 80° 29′). An ore band is reported to occur here on the horizon of the Balaghat deposit, but no details are given (**F.** 727).

UKUA (21° 58 : 80° 32′). The ore band occurs on the same horizon as at Balaghat, and is exposed for a total length of 3 miles. The maximum thickness observed is about 19 feet. The ore is variable in composition, the south-western portion of the band consisting mainly of hard grey, often cavernous, psilomelane ; while the north-eastern portion consists of a mixture of psilomelane and braunite. It is interbanded with quartzite and some gondite. Analysis (average of both varieties) :—Mn=51·54 : Fe=7·38 : SiO_2=3·86 : P=0·18 : H_2O=0·35 per cent. (**F.** 727).

Manganese ore is also reported from the following localities, but without details (**F.** 732) :—

DHARAMPUR (21° 58′ 30″ : 80° 37′).
KANARIDHA (21° 58′ : 80° 39′).
JAIRASI (22° 4′ : 80° 52′).
KURTHITOLA (21° 57′ : 80° 18′). In scattered blocks.
PARSATOLA (22° 2′ : 80° 50′). Pebbles of lateritic ore.

DHARPIWARA (21° 53′ : 80° 15′). Pisolitic nodules of mixed oxides of iron and manganese.

BODRAGHAT (22° 8′ : 80° 47′). Quartz partly replaced by pyrolusite and psilomelane.

The average annual production of manganese ore in the Balaghat district, during the five years 1909 to 1913, was 159,156 tons. In 1914 the output was 221,159 tons, in 1915, 180,609 tons, and in 1916, 264,032 tons.

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Bhandara.—The manganese ore deposits of this district occur as lenticular bands, associated with gondite rocks, in a series of quartzites, schists, and gneisses, which forms an extension of the manganiferous zone of western Balaghat. These rocks occupy an area 20 miles in length, with a maximum width of 18 miles, in the north-western portion of the district. Three groups of deposits have been distinguished.

Group I :—

KOSUMBAH (21° 38′ : 79° 42′ 30″). Outcrop seven-eighths of a mile in length, forming a line of low hillocks about ¼ mile to the N. W. of the village. There are possibly three lenticles of ore on one line of strike. Of these the most southerly consists of a fine grained mixture of psilomelane and braunite, while those to the north, where the outcrop is from 20 to 25 feet wide, mainly consist of 'speckled ore.' Analysis (average of both varieties) :—Mn=50·62 : Fe=10·10 : SiO_2=3·95 : P=0·138 : H_2O=0·40 per cent. (**F.** 736).

SITAPATHUR (21° 42′ : 79° 43′ 30″). Ore band traced at intervals for a total distance of 1⅛ mile. Width from 12 to 20 feet. The principal ore body occurs on Sitapathur hill, where it consists of a hard grey mixture of psilomelane and braunite. In other places it is represented by spessartite-bearing rock with patches of ore. Analysis :—Mn=51·70 : Fe=8·14 : SiO_2=6·19 : P=0·10 : H_2O =0·17 per cent. (**F.** 739).

SUKLI (21° 39′ : 79° 44′). Probably an extension southwards of the Sitapathur band. Total length of outcrop about 450 yards. The ore is variable in character, consisting partly of 'speckled ore' and partly of the braunite-psilomelane mixture. Total production, 1905 to 1913 inclusive, 123,715 tons. Analysis :—Mn=54·07 : Fe =4·30 : SiO_2=2·30 : P=0·13 : H_2O=1·00 per cent. (**F.** 742).

HATORA (21° 37′ : 79° 52′ 30″). Ore band over half a mile in length. The outcrop consists mainly of gondite with little visible ore, but on development an ore body of workable dimensions was met with. Average analysis (2 samples) :—Mn=52·70 : SiO_2=7·10 : P=0·071 per cent. (**F.** 744).

MIRAGPUR (21° 38 : 79° 54′). Six separate masses of ore are exposed on a group of low hillocks situated to the E. of the village. These are probably remnants of a single ore band, broken up by violent earth movements. The ores consist mainly of the hard grey braunite-psilomelane mixture, interbanded with quartzite and gondite. There is also a considerable quantity of talus ore. Total production, 1905 to 1913 inclusive, 131,197 tons. Analysis :—Mn=

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49·81 : Fe=8·74 : SiO_2=5·89 : P=0·09 : H_2O=0·34 per cent. (**F.** 745).

MOHUGAON GHAT (21° 37′ : 79° 54′). Outcrop of gondite 4 feet in width, partly altered to manganese ore (**F.** 750).

PANDARWANI (21° 36′ 30″ : 79° 54′). Detrital ore, derived from the Miragpur deposit. Fragments of ore also occur about 350 yards to E. S. E. of the tank situated on the S. E. side of the village (**F.** 750).

SALEBADDI (21° 40′ : 79° 56′). A small quantity of detrital ore, found in pits situated about ¾ mile to E. 12° S. from the village (**F.** 750).

CHIKHLA II (21° 41′ : 79° 58). A small quantity of detrital ore of good quality. Analysis :—Mn=53·76 : Fe=5·12 : SiO_2=6·47 : P=0·06 : H_2O=0·64 per cent. (**F.** 750).

Group II :—

KURMURA (21° 32′ : 79° 44′). Outcrop about 1¼ mile in length, forming the crest line of a range of hills. Maximum width of the ore band 40 feet, measured horizontally. It consists of gondite, altered in places into ore of good quality ; partly a mixture of braunite and psilomelane, and partly of pyrolusite with psilomelane, the latter probably predominating. There is also a considerable quantity of detrital and pisolitic ore. Average analysis (3 samples) : —Mn=51·11 : Fe=5·58 : SiO_2=4·09 : P=0·22 : H_2O=0·34 per cent. (**F.** 751).

CHIKHLA I (21° 33′ : 79° 49′). Ore band traceable for about 2¾ miles, with a maximum width of 80 feet, measured horizontally. The principal ore body occurs near the western end of the band on Bhamasur hill, and consists of the braunite-psilomelane mixture with numerous bands of gondite and quartzite, traversed by veins and strings of quartz. There are also deposits of talus ore from 10 to 16 feet in thickness. Total production, 1901 to 1913 inclusive, 384,452 tons. Average analysis (9 samples) :—Mn=50·69 : Fe=7·95 : SiO=8·16 : P=0·114 per cent. (**F.** 755).

SITASAONGI (21° 31′ : 79° 48′). Four parallel ore bands, occurring along the crest and northern slopes of Dholi hill. The three northern bands are from 2 to 3 yards in width, and consist of gondite with patches of manganese ore, probably of little economic value. The main ore band, forming the ridge of the hill, is traceable for about 1,200 yards, and varies in width from 12 to 53 feet. It is composed of interbanded gondite and quartzite, with patches of workable ore towards the eastern end of the outcrop. There is also a fair quantity of talus ore on the southern slopes of the hill.

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Average analysis (2 samples) :—Mn=53·29 : Fe=4·83 : SiO_2=6·26 : P=0·085 : H_2O=0·21 per cent. (**F.** 760).

ASALPANI (21° 30′ : 79° 43′). Outcrop about three quarters of a mile in length, consisting of gondite interbanded with quartz and quartzite, partly altered into very siliceous ore. No workable ore is visible at the surface (**F.** 763).

KARLI (21° 30′ : 79° 45′). Outcrop situated on the S. E. slope of a hill known locally as Saya Hurki, about a mile to the N. W. of the village. The ore band exposed is about three-eighths of a mile in length, varying from 2 to 12 feet in width. It is very variable in character, consisting of spessartite and rhodonite rock partly altered to ore, interbanded with vitreous quartzites. Ore bodies of variable quality occur in places, and there is a considerable quantity of talus ore (**F.** 765).

Group III :—

PACHARA (21° 26′ 30″ : 79° 50′). The ore band forms a practically horizontal, lenticular bed, cropping out on the southern and south-eastern slopes of a quartzite hill, about a mile to W. N. W. of the village. The thickness of the bed varies from a few inches to 5½ feet. It is composed of the psilomelane-braunite mixture passing into soft dirty ore in places, mixed with limonite. Analysis :—Mn=52·09 : Fe=3·86 : SiO_2=2·61 : P=0·166 : H_2O=1·15 per cent. (**F.** 767).

The average annual production of manganese ore in the Bhandara district, during the five years 1909 to 1913, amounted to 118,961 tons. In 1914 the output was 82,055 tons, in 1915, 78,627 tons, and in 1916, 86,344 tons.

Bilaspur.—Two occurrences of manganese ore, in rocks mapped by King (**987**—32) as belonging to the Chilpi Ghat series, have been briefly described by Fermor (**577**—34). Neither of these appears to be of economic importance :—

RATANPUR (22° 17′ : 82° 14′). Fragments of psilomelane, pyrolusite and wad, scattered over the eastern slopes of a hill situated about a mile to N. E. of the village. The ores have apparently been formed by the surface replacement of felspathic grits and quartzite, which were found to be cemented and veined by ore within a depth of 6 feet, passing downwards into unaltered rock.

GORAKONA (KAMRAKHOL, 22° 19′ : 81° 26′). The deposit consists of nodular fragments of psilomelane and pyrolusite, with remnants of quartz, chert, and quartzite, and has been traced for about three quarters of a mile along the foot of a hill between Gorakona and Munmuna.

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Chhindwara.—The manganiferous deposits of this district are confined to a portion of the valley of the Kanhan R., which has cut down through the basaltic lava flows of the Deccan Trap formation, and exposed the underlying floor of Archæan rocks. The area in which the deposits occur measures 17 miles in length from north to south, with an average breadth of about 7 miles. The geology of the area has been briefly described by Datta (**424**—4), and with special reference to the petrology and occurrences of manganese ore by Fermor (**577**—6). The ores, associated with manganese silicates (gondites and rhodonite-bearing rocks), form lenticular bands intercalated along the strike of a complex series of metamorphic rocks traversed by intrusive granites and pegmatites. Ore deposits have been found at the following localities, proceeding from north to south :—

KACHI DHANA (21° 43′ : 78° 51′). The outcrop of the ore band forms a line of five hillocks, from 20 to 40 feet in height, extending westwards from a point south of the village for about half a mile. The hillocks apparently correspond to the development of separate lenticular ore bodies along the line of strike. The ore varies in composition, part consisting of a compact mixture of braunite and psilomelane, and part of finely crystalline braunite, with a good deal of unaltered spessartite rock, quartz and felspar, in places. A mass of pyrolusite, with geodes of calcite and quartz, was found in the most westerly hillock. A considerable quantity of high grade ore is available. Total production, 1906 to 1913 inclusive, 140,406 tons. Range of analyses (9 outcrop samples) :—Mn=51·87 — 56·82 : Fe=2·82—5·30 : SiO_2=1·10—16·27 : P=0·004—0·135 per cent. (**F.** 773).

GAIMUKH (21° 46′ : 78° 54′). A lenticular body of ore 60 yards in length by 20 yards in breadth, forming a small hillock situated on the southern side of a low ridge of quartzite. Only the central portion of the deposit, about 20 yards long and 7 yards broad, consists of high grade ore, mainly braunite, the remainder being less altered rhodonite-spessartite rock. The ore contains a certain proportion of unaltered rhodonite and rhodochrosite, and is consequently highly siliceous. Analysis :—Mn=54·98 : Fe=6·19 : SiO_2=10·63 : P=0·044 per cent. (**F.** 781).

Three small outcrops, consisting mainly of braunite, were found near LAKHANWARA village, about 200 yards W. of the Gaimukh deposit, but these have been worked out (**F.** 780).

SITAPAR (21° 44′ : 78° 55′). The outcrop forms an elliptical hillock, 27 yards in length by 25 yards in breadth, and 20 to 25 feet high, surrounded by alluvium, situated about three quarters of a

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mile due W. of the village. On development the ore body was found to be 158 feet in length, and 133 feet thick, including small intrusions of pegmatite. The composition of the ore is unique, including six different minerals, among which are hollandite, sitaparite, and a white arsenate with phosphate (fermorite). Average analysis (2 samples from outcrop):—Mn=54·77: Fe=6·96: SiO_2=7·42: P=0·089: As=0·032 per cent. (**F.** 785).

Bichua (21° 41′ 30″: 78° 55′). A band of spessartite quartz rock is exposed at intervals for about half a mile, forming a range of small hillocks lying to the S. of Burar hill. The rock is only partially altered to ore (**F.** 789).

Alesur (21° 43′: 78° 57′). An outcrop of crystalline limestone with inclusions of spessartite and rhodonite, passing into gondite partially altered into ore. The occurrence is of no economic value (**F.** 790).

Devi (21° 42′ 30″: 78° 57′). An irregular band composed mainly of spessartite, rhodonite, and rhodochrosite, traceable for about a mile along the northern side of a range of low hills of crystalline limestone and calciphyre. The amount of ore is small and it is of low grade. Analysis:—Mn=48·95: Fe=7·03: SiO_2=4·98: P=0·283 per cent. (**F.** 790).

Ghoti (21° 38′: 78° 56′). Two parallel ore bands are exposed, about 750 and 440 yards in length respectively. The shorter band contains the most ore, which is mainly a mixture in about equal proportions of braunite and psilomelane, with intercalated quartzite and felspathic bands. Analysis:—Mn=49·55: Fe=7·71: SiO_2=8·74: P=0·279 per cent. (**F.** 792).

Wagora (21° 36′: 78° 52′). Six parallel bands of gondite associated in places with rhodonite partially altered into ore are exposed, intercalated with granulites, gneisses, and schists. The ore is small in quantity and of very low grade (**F.** 794).

Gowari Warhona (21° 32′: 78° 53′). Ore band with an average thickness of about 6 feet, proved for a total length of 1,600 feet. The ore is of good quality, except towards the S. E. end of the outcrop, where it passes into gondite. Development work has shown that the band is much broken up in places, and traversed by dykes of pegmatite (Fermor, **577**—36, 5). The ore consists of braunite, psilomelane, and hollandite in varying proportions. Analysis:—Mn=53·59: Fe=5·00: SiO_2=6·21: P=0·074 per cent. (**F.** 795).

Dudhara (21° 30′: 78° 57′). Two bands of spessartite-quartz rock, exposed at the base of Dudhara hill, on the S. E. side. The rock has undergone little alteration (**F.** 801).

The average annual output of manganese ore in Chhindwara, during the five years 1909 to 1913, was 26,732 tons. In 1914 the

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production amounted to 87,114 tons, in 1915 to 46,941 tons, and in 1916 to 53,977 tons.

Hoshangabad.—SONTALAI (22° 21′ : 76° 56′). A small outcrop of impure wad, probably due to the superficial replacement of a siliceous rock, is exposed in the road at the west end of the village. The ore contains only 16·73 per cent. of manganese, with small quantities of cobalt, nickel, and copper (**F.** 802).

Jubbulpore.—The existence of manganese ore deposits at Gosalpur was first brought to notice in 1875 by Mr. Olpherts. In 1879 Mallet (**1159**—18) published an analysis of the ore, with a brief note by Medlicott on its mode of occurrence; and further allusion to the deposits was made by Mallet (**1159**—37), in connection with a project for utilising the manganiferous iron ores of this area, when the lateritic origin of the manganese ores was pointed out and discussed. A considerable amount of prospecting work was subsequently (1887-88) carried out by E. J. Jones and P. N. Bose, and the results were published in two separate papers (**173**—9; —11), the first containing a detailed account of the distribution of the deposits, while the second deals with the geology of the manganiferous tract and the origin of the ores.

The deposits are found on the outcrop of two formations, constituting the Lora group, a local member of the Dharwar ('Bijawar') series. This group has been subdivided by Bose into the Sihora beds, consisting of slaty shales and banded hematite quartzites, and, underlying these, the Gosalpur quartzites. The manganese bearing area occupied by these rocks is of a roughly elliptical shape, corresponding with a synclinal basin about 20 miles in length from N. E. to S. W., and from 3 to 5 miles in width, extending from the Lora range, N. E. of SIHORA, (23° 29′ : 80° 10′) to MARHASAN (23° 21′ : 80° 3′).

The ores are entirely of a lateritoid character. Those which occur on the outcrop of the Sihora beds consist of manganiferous hematite and psilomelane, resulting from the concentration at the surface of manganese oxide derived from the hematite quartzites, which are themselves feebly manganiferous. In the final stage the iron ore is almost entirely replaced by psilomelane, the original structure of the rock being practically obliterated. On the outcrop of the Gosalpur quartzites the ore has been developed by the gradual solution of the silica and its replacement by manganese oxide, usually in the form of pyrolusite, so that there is a passage downwards from comparatively pure ore at the surface into fresh quartzite.

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The principal deposits occurring in this area are:—

KASAI HILL (23° 31′ : 80° 8′). A bed of manganiferous limonite, from 36 to 50 feet in width, forms a capping to the hill. In places the limonite is filled with a network of veins of psilomelane, occasionally passing into pure ore. The deposit could not profitably be worked as a source of manganese ore alone (**F.** 820).

DARSHANI (23° 30′ : 80° 8′). Manganiferous limonite, of the same description as that on Kasai hill, forms a capping on a hill five-eighths of a mile to the N. of the village (**F.** 821).

MANSAKRA (23° 30′ : 80° 10′). The deposit here consists of brecciated quartzite cemented by pyrolusite, and limonite with veins of pyrolusite and psilomelane. Bose estimated the amount of pyrolusite available at about 9,000 tons. On development the ore body was found to be about 240 feet long, 120 feet wide, and 10 feet thick. In the year 1907, 7,100 tons of ore were removed from the deposit (**F.** 822).

GHOGRA (23° 29′ : 80° 15′). A band of manganiferous micaceous hematite, probably of considerable thickness, exposed on the southern side of the Lora range. The proportion of manganese varies considerably. An average sample contained:—Mn=12·26 : Fe=46·43 : P_2O_5=0·27 per cent. (**F.** 825).

SAKRI (23° 28′ : 80° 11′). Bands of jaspery hematite passing at the surface into limonite with thin veins of psilomelane. In places the hematite is highly manganiferous, and in some cases has been converted into psilomelane, but the quantity of manganese ore available is small. Analysis:—Mn=22·14 : Fe=19·17 : SiO_2 =23·40 : P=0·06 per cent. (**F.** 826).

BHATADON (23° 27′ 30″ : 80° 12′). A lateritic deposit, consisting of an aggregate of small concretions of wad and limonite. The deposit is of small extent and thickness (**F.** 829).

GOSALPUR (23° 24′ : 80° 7′). The deposits here consist of pyrolusite nodules, with subordinate amounts of psilomelane and iron ore, forming a layer of varying thickness in the soil covering the outcrop of Gosalpur quartzites. The decomposed rock, in which the ore is developed by a process of surface replacement of the silica, also contains veins and nests of pyrolusite. The total quantity of ore available was estimated by Bose, as the result of prospecting operations, at about 50,000 tons; but according to Fermor, the amount of merchantable ore is much less than this. A considerable quantity of the highest grade ore has been removed by glass workers. Analysis:—Mn=54·66 : Fe=3·17 : SiO_2=2·74 : P=0·12 per cent. (**F.** 831).

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DHARAMPURA (23° 23′ : 80° 5′ 30″). A band of hematite jasper, highly manganiferous at intervals, is exposed along the crest of a ridge running S. W. from Gosalpur through Dharampura to MARHASAN (23° 21′ : 80° 3′). In places the rock is converted into psilomelane. Pyrolusite also occurs, according to Bose, on an outcrop of Gosalpur quartzite at the foot of a hill locally known as CHANGELI, about a mile to W. N. W. of Dharampura. The quantity of dressed ore available was estimated at 13,000 tons (**F.** 833).

NONSAR (23° 14′ : 79° 51′ 30″). Bose records the existence of manganiferous hematite and psilomelane on a patch of Lora rocks at this locality (**F.** 835).

Nagpur.—The existence of manganese ore in this district was recorded in 1829 by Jenkins (**938**—1, 208, 212), who mentions its occurrence in the valley of the Pench R. at GOKALA (?GHOGARA) 3 or 4 miles above NAYAKUND (21° 22′ : 79° 15′); and in the jungle about 4 miles to the N. of KUMARI (21° 26′ 30″ : 79° 23′ 30″) where the ore was found associated with crystalline limestone. In 1859 a deposit at MANSAR HILL was discovered by Oakes (*see* Ball, **71**—45, 329). A sample of the ore, afterwards analysed by Mallet (**1159**—17), was found to consist of braunite with a little rhodonite, and to contain 55·27 per cent. of manganese. W. T. Blanford also discovered one of the deposits at KODEGAON in 1872 (*see* Mallet, *l. c.*, 74); but it was not until the beginning of the present century that active prospecting led to the discovery of the immense resources of manganese ore that are possessed by the district.

The manganese ores of Nagpur occur in a belt of Archæan rocks, which forms a continuation westwards of the manganiferous zone of Bhandara and western Balaghat. The belt measures 31 miles in length from east to west, with a maximum breadth, as at present known, of about 11 miles. At the western end it is cut off by a fault, which has brought rocks belonging to the Kamthi division of the Gondwana system into contact with the metamorphics. The rocks comprised in the belt are of the same character as those described by Fermor (**577**—6) in the Chhindwara manganese area, including acid and pyroxene gneisses, hornblende and mica schists, quartzites, crystalline limestones and calciphyres, arranged in parallel, discontinuous bands.

In accordance with their mode of occurrence, the ore deposits have been divided by Fermor into two classes:—

I. Ores occurring as bands, often of considerable length and usually thinning out in a lenticular manner, intercalated between

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the gneisses, schists, and quartzites, and associated with spessartite-quartz rock (gondite), rhodonite rock, or with both.

II. Lenticles or bands of nodules of ore in crystalline limestone, usually associated with piedmontite.

These two classes are again subdivided into groups according to the geographical distribution of the deposits :—

Class I, Group I :—

KODEGAON (21° 25′ : 79° 1′). There are apparently two separate ore bodies here, occurring on the same line of strike. No. 1, situated about a quarter of a mile to S. W. of the western end of the Kodegaon hills, was found on being opened up to be at least 205 feet in length, and 115 feet in width measured horizontally. The whole mass consists of a mixture of two parts of braunite and one of psilomelane, with very little foreign material. No. 2, situated at the northern foot of the same hills, measured 300 feet in length in 1907, the width varying from 20 to 80 feet. The ore is of inferior quality, containing many patches of unaltered gondite and quartzite, and appears to deteriorate in depth. A large mass of granitic rock was met with in the centre of the deposit. Total production, from 1903 to 1913 inclusive, 131,523 tons. Analysis (average sample from both deposits) :—Mn=52·54 : Fe=7·60 : SiO_2=4·08 : P=0·10 : H_2O=0·28 per cent. (**F.** 845).

GUMGAON (21° 25′ : 79° 3′). The deposit forms a band exposed for about 1,200 feet, along the southern slope of a hill between Gumgaon and Khapa villages. The width of the band is about 300 feet, but only 50 feet represents ore *in situ*, the remainder being composed of gondite rock. The ore is variable in quality, passing from a hard braunite-psilomelane mixture into soft sooty ore and a variety much contaminated by residual quartz. Total production, from 1901 to 1913 inclusive, 101,721 tons. Analysis :—Mn=53·05 : Fe=5·565 : SiO_2=4·47 : P=0·12 : H_2O=0·33 per cent. (**F.** 852).

RAMDONGRI (21° 24′ 30″ : 79° 5′). Three distinct lenticular ore bodies are exposed, each forming a separate hill or hillock. The largest measures about 2,500 feet in length, by 1,500 feet in width (the great widths recorded here are perhaps due to folding), and rises to a height of about 140 feet above the low ground. The others measure about 1,500 feet by 700 feet and 450 feet by 90 feet respectively. Each of the deposits is mainly composed of gondite rock, and the amount of merchantable ore is not great. It consists largely of the braunite-psilomelane mixture, but there is also a certain proportion of coarsely crystalline braunite. In connection with the largest deposit a considerable quantity of talus ore was being

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worked in 1903. Average analysis (4 samples) :—Mn=52·97 : Fe =6·80 : SiO_2=6·43 : P=0·09 per cent. (**F.** 855).

Group II :—

RISARA (21° 28′ : 79° 3′ 30″). Three outcrops were observed, situated about half a mile from the village to E. by-N., N. E., and E. N. E. respectively. In each case they are composed of spessartite-quartz rock, partially altered into ore of low grade. Analysis : —Mn=34·68 : Fe=2·26 : SiO_2=23·46 : P=0·43 : H_2O=1·02 per cent. (**F.** 860).

Outcrops of spessartite-bearing rock were also found in the jungle at the southern end of the ridge on which the village of NANDGONDI (21° 30′ : 79° 7′) is situated, and in the SITAGONDI (21° 29′ : 79° 8′) jungle. In neither case was any merchantable ore seen (**F.** 861).

Group III :—

KANDRI (21° 25′ : 79° 20′). The ore band forms a horse-shoe shaped curve about half a mile in length, and is exposed in three hills. Two of these, 260 feet (S.) and 210 feet (N.) in height respectively, are composed, except as regards the saddle connecting them, of high grade ore, varying in thickness from about 60 to 87 feet; while the third hill, lying to the east of these, is composed of gondite and spessartite-bearing quartzite, often converted into ore, but not sufficiently so to be workable. At the S. E. end of the outcrop, the ore body dips beneath the surface, and has been struck in a boring at a depth of 65 feet. The ore consists mainly of braunite with a certain proportion of psilomelane; the hardness and compactness depending on the quantity of the latter mineral that is present. The proportion of psilomelane has been found to decrease rapidly in depth, with a consequent deterioration in the physical character of the ore. Total production, from 1900 to 1913 inclusive, 488,814 tons. Range of analyses of ore despatched :— Mn=54—57 : Fe=3—5 : SiO_2=8—10 : P=0·08—0·12 per cent.

Large quantities of talus ore have been quarried from the southern and south-western slopes of the south hill (**F.** 862).

MANSAR (21° 24′ : 79° 20′). The outcrop of the ore band has been traced for a distance of 1¼ mile, in a general E. S. E. direction, along the crest and south-eastern slopes of Mansar hill, which rises to a height of 350 feet above the plain. For about two-thirds of its length, on the crest of the hill, the band consists almost entirely of high grade ore, very uniform in composition, with an average thickness of 45 feet; but towards the south-east the ore is replaced to a great extent by manganese silicate rocks. In depth also the

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ore has been found to contain masses of partially converted spessartite and rhodonite rock, the cleaned ore amounting to about 30 per cent. of the total extracted. A considerable quantity of talus ore has been quarried from the northern and western slopes of the hill. The ore consists largely of braunite, with hard bands cemented by psilomelane. Average analysis (2 samples) :—Mn=54·46 : Fe=4·82 : SiO_2=8·36 : P=0·07 per cent. (**F.** 878).

A continuation of the ore band, known as the Mansar Extension, has been exposed by excavation beyond the N. W. end of the hill, for a distance of about 200 yards. The ore in this portion of the band consists of soft braunite, much interlaminated with gondite and quartzite. Analysis :—Mn=52·27 : Fe=5·07 : SiO_2=16·77 : P=0·17 : H_2O=0·60 per cent. (**F.** 891).

From 1900 to 1913 inclusive the Mansar hill deposits produced 331,529 tons of ore.

PARSODA (21° 23′ : 79° 22′). The ore here, exposed in a pit surrounded by alluvium, probably lies on an extension to the S. E. of the Mansar band. About 650 tons of ore, containing from 49 to 53 per cent. of manganese, were extracted from the deposit in 1904 and 1905 (**F.** 893).

BORDA (21° 27′ : 79° 20′). Loose fragments of ore, up to 2 feet in diameter, were found in shallow excavations at the base of a hill of vitreous quartzite, about half a mile to N. of the village. The ore resembles that of Mansar hill in composition (**F.** 895).

Group IV :—

PARSIONI (21° 22′ : 79° 13′)—BANSINGHI. The ore band is about 2 miles in length from E. to W., with an average thickness of about 50 feet. At the outcrop manganese silicate rocks, interlaminated with quartzites, alone were seen; but beneath the surface they were found to be partially converted into ore. About 1,200 tons of ore were extracted from the deposit during 1906 and 1907 (**F.** 897).

DUMRI KALAN (21° 20′ : 79° 18′). This occurrence forms the western termination of a line of deposits (noted below) extending eastwards for about 12 miles. About 120 tons of fragmentary, low grade ore were extracted from an excavation, but none was apparently found *in situ* (**F.** 898).

SATAK (21° 20′ : 79° 19′ 30″). The total length of the ore band within the village limits is about three quarters of a mile. Only two portions of the band, lying on either side of the village, were found to contain workable ore, the remainder consisting of manganese silicate rocks. In the western portion braunite was found *in situ*, much contaminated in places with manganese garnet. In the

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eastern portion, which forms a low mound about a quarter of a mile in length, the ore *in situ* is very impure, much interbanded with gondite and quartzite, and traversed by felspathic intrusions; but the talus ore was of better quality, and occurred in beds up to 10 feet in thickness. The total quantity of ore raised from these deposits, during the years 1904 to 1907, amounted to 17,901 tons (**F.** 899).

BELDONGRI (21° 20′: 79° 21′). The original outcrop here, a mass of spessartite-rhodonite rock projecting a foot or two above the surface of the alluvium, is worshipped as a deity by the villagers, and has been preserved from quarrying. The ore body, as opened up in 1906, was nearly 300 feet in length and about 60 feet in actual width. About half of this thickness is rendered worthless by patches of manganese silicates not converted into ore, and by bands of schist and quartzite. The ore varies in physical character according to the proportion of psilomelane present, from friable granular braunite to hard compact varieties composed of about equal quantities of the two minerals. Some of it consists of a variety resembling metallic lead, to which the name 'beldongrite' has been given. Vredenburgite also occurs at this mine. Total production, from 1901 to 1907 inclusive, 26,294 tons. Average analysis (2 samples):—Mn=53·70: Fe=5·53: SiO_2=4·94: P=0·06: H_2O=1·02 per cent. (**F.** 904).

NANDAPURI (21° 20′: 79° 23′). The deposit here consists of talus ore, occurring beneath 2 feet of surface soil, overlying a mass of gonditic rock. About 500 tons of ore were raised in 1907 (**F.** 912).

A deposit of similar talus ore was also found in a pit at NAGARDHAN, a short distance to the W. of Nandapuri (**F.** 911).

LOHDONGRI (21° 19′ 30″: 79° 25′). The ore body here, before being opened up, formed a low mound about 380 yards in length, 200 yards in breadth, and 30 to 35 feet high. It consists of a succession of distinct layers of ore, varying in thickness from 2 inches to 2 feet or more, occasionally horizontal, but much crumpled by folding. Practically the whole of the deposit is composed of workable ore, either coarse crystalline braunite, or fine grained psilomelane with patches of braunite; but layers of quartzite occur in some places. The thickness of the deposit may amount to 60 feet. Production, from 1900 to 1913 inclusive, 245,163 tons. Range of analyses:—Mn=47·12—50·64: Fe=7·32—10·62: SiO_2=6·40—7·45: P=0·054—0·098 per cent.

There is reason to believe, from the evidence afforded by pits, that this deposit may be connected beneath the surface with that of Beldongri, further west (**F.** 914).

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KACHARWAHI (21° 20′ : 79° 27′). This deposit is exposed by an excavation in the alluvium, about three quarters of a mile to S. by E. of the village. The ore body measures about 100 yards in length, 92 feet in width, and in 1906 had been opened up to a depth of about 60 feet in places. It is composed of layers of ore from 5 to 10 feet thick, interbedded with layers of hard vitreous quartzite and soft schistose rocks of about equal thickness. The ore itself is also interlaminated in places with thin bands of quartzite, and with intrusive felspathic rocks carrying crystals of braunite and blanfordite and rendered worthless. The ore consists of a fine to coarse grained mixture of braunite and psilomelane. Total production, from 1904 to 1907 inclusive, 20,720 tons. Average analysis (7 samples) :—Mn=52·81 : Fe=6·55 : SiO_2=7·57 : P=0·069 : H_2O=0·28 per cent. (**F.** 922).

WAREGAON (21° 20′ : 79° 28′ 30″). The deposit was opened up in 1902-04 by an excavation in the alluvium, but work was discontinued in the latter year on account of the influx of water. The ore band was exposed for a length of about 300 feet and was about 30 feet thick. A second ore band was found in trial pits about 200 feet to the west of the main excavation. The ore is said to have become poorer in quality with depth, and the last consignment is reported to have been very arsenical. The output is said to have been about 30,000 tons. Average analysis (8 samples) :—Mn=50·45 : Fe=8·22 : SiO_2=6·88 : P=0·068 : H_2O=0·50 per cent. (**F.** 929).

KHANDALA (21° 20′ : 79° 29′). An outcrop of gondite and rhodonite rock occurs on the right bank of the Sur R., a mile E. by N. of the village. The band is traceable for about 180 yards, and may be 24 yards wide. In places the gondite is converted into ore of poor quality. About 200 tons were extracted in 1907 (**F.** 932).

Group V :—

MANDRI (21° 25′ : 79° 27′). Here there are two ore bands, lying on the south-eastern side of two small hills of quartzite. They are roughly parallel to each other, and about 100 yards apart. Both are much bent and contorted. The northern measures about 270 yards in length along the bends, and the southern about 590 yards; the respective widths are 6 to 14 feet, and 24 to 40 feet. They appear to be cut off by a fault at the western end. The ores are usually soft and black, with remains of unaltered spessartite rock and quartzite; but there is also a certain proportion of hard grey ore. About 36,000 tons of ore were raised from this deposit during the years 1904 to 1907. Average analysis (5 samples) :—Mn=53·23 : Fe=5·27 : SiO_2=6·04 : P=0·106 : H_2O=0·73 per cent. (**F.** 934).

PANCHALA (21° 24′ : 79° 28′). The ore band occurs on the line of strike of the southern band at Mandri, and is probably conti-

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nuous with it. The length exposed is about half a mile. The beds are much folded parallel to the strike, and consist of spessartite and rhodonite rock largely converted into ore, which is partly a hard and crystalline braunite-psilomelane mixture, and partly sooty and 'speckled' ore. About 2,300 tons were extracted during 1906-07. The ore contains 47·58 per cent. of manganese (**F.** 941).

MANEGAON (21° 26′ : 79° 28′). Two ore bands are exposed here, lying on the southern slopes of a ridge composed of micaceous quartzite. The main band is about a mile and a half in length, with an average width of about 50 feet. The other band is quite subordinate, being only about 600 yards in length. Both are composed to a large extent of unaltered spessartite and rhodonite rock, but there is a fair quantity of merchantable ore varying from hard grey psilomelane to a soft, sooty ore with braunite grains. Total production, from 1904 to 1907 inclusive, 40,598 tons. Analysis :—Mn= 49·15 : Fe=10·26 : SiO_2=5·31 : P=0·09 : H_2O=0·35 per cent. (**F.** 942).

GUGULDOHO (21° 26′ : 79° 29′). This ore band may be a continuation of the Manegaon deposit, but is separated from it by a hill of quartzite. It is about a mile and a half in length, but only about 350 yards of this length, on the crest of Guguldoho hill, contains workable ore; the remainder being composed of spessartite and rhodonite rock, with patches of manganese in places. The ore body varies from 15 to 40 feet in thickness, and is largely composed of the sooty variety known as 'speckled' ore. Near the surface it frequently becomes concretionary. Production during 1906 and 1907, about 3,400 tons. Analysis :—Mn=46·24 : Fe=16·34 : SiO_2 =2·90 : P=0·183 : H_2O=0·54 per cent. (**F.** 947).

BHANDARBORI (21° 24′ : 79° 31′). Boulders of soft gondite, partially altered to manganese ore, were seen in shallow pits about half a mile to N. N. W. of the village, on the strike of the Mandri-Panchala deposit (**F.** 953).

Class II :—

The manganese ores of this class occur in the form of lenticular masses, small beds, or bands of nodules in crystalline limestones, usually in too small quantity to be worked *in situ*, though the residual accumulations of nodules left on the surface by the weathering of the limestone would often pay to work. Occasionally the limestone itself is charged with manganese, which may amount to as much as 18 per cent. The following deposits have been noted :—

MOHUGAON (21° 27′ : 79° 5′). Outcrop about 220 yards in length, situated about a mile to E. S. E. of the village. The ore is

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probably a mixture of braunite and hollandite, containing 17·79 per cent. of manganese (**F.** 955).

PALI (21° 26′ : 79° 15′). Outcrop situated to N. and N. E. of village, exposed for about 1,400 yards. The limestones, especially along the centre of the deposit, are often blackened by manganese, and contain nodules of braunite and hollandite. Masses of pyrolusite occur in places, containing a high percentage (73—96) of manganese dioxide, and sufficiently pure to be used in the manufacture of chlorine or for glass making (**F.** 957).

GHOGARA (21° 23′ : 79° 14′). Outcrop exposed in the bed of the Pench R. for about a quarter of a mile across the strike. The manganiferous portion of the band measures about 100 feet in thickness, and contains numerous nodules and lenticles of ore, arranged in lines following the bedding planes of crystalline piedmontite limestone (**F.** 961).

MANDVI BIR (21° 28′ : 79° 17′)—JUNAPANI (21° 29′ : 79° 21′ 30″). The deposits consist of lenticular masses and nodules of manganese ore enclosed in a band of crystalline limestone, which has been traced for more than 6 miles from east to west. A second parallel band, about 220 yards to the south, is believed to be a repetition of the northern band, brought up by a synclinal fold. The masses of ore are occasionally of considerable size, especially near the eastern (Junapani) end of the deposit, where there appears to be a definite bed, varying from 4 to 10 feet in thickness. Considerable quantities of residual nodular ore, derived from the limestone by weathering, have been quarried from the whole length of the band. Production during 1906 and 1907, about 20,500 tons. Range of analyses :—Mn=50—52 : Fe=2—4 : SiO_2=5—9 : P=0·05—0·12 per cent. (**F.** 965).

RAJKOTA (21° 29′ : 79° 24′ 30″). An outcrop of manganiferous limestone, perhaps representing a continuation eastwards of the Mandvi Bir-Junapani band (**F.** 976).

The average annual output of manganese ore in the Nagpur district, during the five years 1909 to 1913, was 183,575 tons. In 1914 the production amounted to 174,562 tons; in 1915 it fell to 93,027 tons, but rose in 1916 to 153,899 tons.

Nimar.—Four occurrences of manganese ore have been noted, all due to surface impregnation and replacement. The ores are of poor quality (**F.** 977) :—

CHANDGARH (22° 15′ 30″ : 76° 40′·30″). The Lameta rocks exposed in a stream bed about a quarter of a mile to S. E. of the village are blackened in places by impregnations of manganese oxide.

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GOHUGAON (22° 15′ : 76° 48′). Outcrops of manganiferous breccia are exposed for about 200 yards along the banks of the Jamdihi stream, a mile and a quarter to N. N. W. of the village. The matrix of the breccia consists of wad and hard grey psilomelane.

Further down the stream, about three-eighths of a mile from its junction with the Narbada R., a hard layer of calcareous rock at the base of the Deccan trap contains manganese garnet.

About half a mile above the manganiferous breccia deposit noted above, an outcrop of Vindhyan shales occurs in a small tributary stream. These show small patches of secondary pyrolusite and psilomelane.

Seoni.—The southern end of this district projects into the Nagpur Balaghat manganiferous belt, and Burton (*see* Hayden, **793**—31, 21) has recorded the occurrence of small deposits of manganese ore at the following localities :—

CHICHULDOH (21° 46′ : 79° 45′). An outcrop of blue quartzite, associated with gondite partially converted into manganese ore, was found at the western edge of a small hillock about 250 yards to the N. of the village. A small deposit was also seen in a stream bed half a mile to S. W. of the village.

DHOBITOLA (21° 42′ 30″ : 79° 43′). Three occurrences were seen in this neighbourhood :—

1. A quarter of a mile to W. of the village. Quartzite impregnated with manganese, interbedded with thin bands of fairly pure ore.

2. On the Dhobitola-Dulapur road, 200 yards E. of the Thuyaghat stream. A small band of ore.

3. A small outcrop on the road, 600 yards W. of the same stream.

KHIRKI (21° 43′ : 79° 41′). On the Bhandara-Seoni boundary, S. W. of the village. Quartzite impregnated with ore.

Yeotmal (Wun).—Hughes (**888**—17 ; —20, 76) has recorded the occurrence of botryoidal masses of psilomelane in Kamthi clays at the base of Malagarh hill (19° 56′ : 79° 6′). According to an analysis by Tween, the ore contains 44·6 per cent. of manganese oxide (**F**, 979).

GOA.

The manganese ore industry of the Portuguese territory of Goa dates from the beginning of the year 1906, when the first *manifesto*, or license to work the deposits, was issued to Haji Ismael Mirza Bagdadi. Before this, the existence of the ore in the province appears to have been unknown.

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The ores occur chiefly in thick beds of ferruginous laterite, resting upon an uneven surface of Dharwar rocks, and partly in the decomposed quartzites and phyllites lying beneath the laterite. In the latter case the ore appears to have been formed by a process of replacement of the silica; while that in the laterite is probably either due to the segregation of the oxides of manganese and iron brought up in solution from the underlying rocks, or is partly of a residual character, representing the ore that was developed in the quartzites prior to the formation of the laterite. The ore is usually pyrolusite, associated in places with a certain amount of psilomelane and wad, and is often mixed with iron ore and with fragments of quartz and other rocks. It is, therefore, highly ferruginous, and seldom contains as much as 50 per cent. of manganese (**F.** 980).

The following deposits occur in the neighbourhood of BICHOLIM (15° 35′ : 74° 1′):—FANUSWADI; DAB DABBA (2 deposits); VAOTIM; KOLAMBI; KULAN (CULON); FERINGESEY BAT; and SERVONA.

Deposits have also been reported to occur at:—

KANDIAPAR (15° 25′ 30″ : 74° 6′). Here the ores are said to be mainly psilomelane.

KORQUI (KUDKEE, 15° 31′ : 74° 12′).

KURADO (15° 22′ : 74° 14′).

MALPONA (15° 27′ : 74° 14′).

MORLEM (15° 35′ 30″ : 74° 6′).

The following localities are not marked on the map:—

MALAN; 2 miles to N. of Kalay railway station.

VILLIAN, KUMARI, and KAJRI; near PERITEM, 16 miles to S. of Sanvordam railway station.

AVODUPALLE, CHENDO, and KARAPUR.

The total quantity of Goanese ore shipped from the port of Mormugao during the five years 1909 to 1913 was 16,243 tons.

HYDERABAD.

Bidar.—Newbold (**1294**—18, 245) in 1840 recorded the existence of manganese ore in the laterite forming the plateau of BIDAR (17° 55′ : 77° 36′), and in 1844 (**1294**—32, 992) described its occurrence more particularly at the base of a scarp near the village of HULFERGAH (? HALBURGA, 18° 0′ : 77° 23′ 30″), 16 miles to W. by N. from Bidar. The laterite is traversed by a network of veins of manganese ore, about an inch in thickness near the base of the cliff, and gradually diminishing in width as they ascend, until they are lost in the substance of the laterite. The ore consists of black manganese oxide combined with iron, often compact and hard, but sometimes earthy and friable (**F.** 989).

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MADRAS.

Bellary.—TELIGI HILL (14° 39′ : 75° 57′). Manganese ore is said to occur in the western spurs of the hill, which is situated on the Dharwar-Shimoga band of Dharwar rocks crossing the western edge of the district. A specimen of the ore consisted of a cavernous mixture of nodular pyrolusite and limonite (**F.** 992).

(Sandur State).—The existence of manganese ore in the Sandur hills was first mentioned by Newbold (**1294**—13, 125) in 1839. Fifty years later, Foote (**596**—34, 26) noted the occurrence of concretionary manganiferous nodules in 'argillites' on the slopes below Ramandrug; and in his memoir on the geology of the Bellary district (**596**—39, 194) added three other localities at which similar nodular deposits were found in sufficient quantity, as he supposed, to be worth exploiting. These deposits, however, in comparison with the massive beds of ore which have since been found to exist on the summit of the hills, are now considered to have little economic value. The discovery of the plateau deposits is due to Ghose, who has given an elaborate account (**652**—3) of their geological relations, mode of occurrence, and distribution, and has also discussed their origin. A description of the deposits has also been published by Ahlers (**16**—2), the manager of the mines worked by the General Sandur Mining Co., Ltd.

The Sandur hills are composed of bands of schists, phyllites, and ferruginous quartzites, in ascending order, with interbedded igneous rocks in the two lower formations, probably representing intrusive sills. The rocks are disposed in a great synclinal trough, of an elongated oval form, with its longer axis directed from N. W. to S. E. The manganese ores are almost entirely confined to the crest and western slopes of the western limb of the synclinal, and are chiefly developed on the outcrop of the bands of phyllite, which have been impregnated and replaced by the ore to a depth, in some cases, of as much as 100 feet, though the usual thickness of the deposit is somewhat less than this. The ores commonly retain the laminated structure and high dips of the phyllites, and often include partially altered patches of the original rock. At their base they pass downwards into a zone of lithomarge, which often contains nodules and bands of ore. The ores therefore belong to the group designated 'lateritoid' by Fermor. At the summit of the hills they are often overlaid by horizontal sheets of laterite, which probably represents the final stage in the alteration of the rock, in which the manganese is replaced to a large extent by oxide of iron (**F.** 993).

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It should be mentioned that Ghose (*l. c.*, 264) rejects the theory of superficial replacement in accounting for the formation of the ores, and considers that they are of a sedimentary origin, deposited on the floor of the Archæan sea in connection with submarine and contemporaneous discharges of volcanic material. This hypothesis, however, appears to account satisfactorily for none of the special features of the deposits, except the lamination which gives their bedded appearance to the ores. This character indeed appears to constitute the main argument in favour of the theory.

The principal constituents of the Sandur ores are psilomelane and wad. Pyrolusite and manganite of secondary origin often occur in cavities. Braunite and hollandite may also occur, but are quite subordinate in amount. The characters and mode of occurrence of the manganite have been described in special papers by Fermor (**577**—7) and Ghose (**652**—2). The ores are not as a rule of high grade, though the proportion of silica and phosphorus is low. They usually contain a considerable percentage of iron oxide. Average analysis (4 samples) :—Mn=45·05 : Fe=12·33 : SiO_2=0·89 : P=0·011 per cent.

The total quantity of ore (including ferruginous manganese-ores) available in the Sandur hills is roughly estimated by Fermor (**577**—32, 1014) at about 10 million tons. Ghose (**652**—3, 253) has estimated the quantity contained in thirteen deposits on the Kammat Haruvu plateau at 1,306,782 tons.

The number of separate deposits discovered by Ghose amounts to about 100, distributed along the plateaus which form the crest of the range, from KAMMAT HARUVU (15° 1′ : 76° 40′ 30″) in the S. E. to the neighbourhood of RAMANDRUG (15° 7′ 30″ : 76° 32′) in the N. W. It was found that many of the deposits were known to the villagers by descriptive names, such as Alada-marada-banda, 'Banyan tree outcrop,' bestowed on them in order to assist in their identification as landmarks, but not connected in any way with their mineralogical character, which appears to have been unknown to the people. The deposits are divided into ten groups :—

Group.	No. of deposits.	Group.	No. of deposits.
I. KAMMAT HARUVU .	28	VI. SUBRAYANHALLI RANGE	8
II. HANUMANTHANA HARUVU.	4	VII. TUMBARAGADDI FOREST	3
III. TONASHIGRI FOREST .	6	VIII. KANEVIHALLI RANGE	11
IV. MANNAL HARUVU .	10	IX. RAMANDRUG RANGE .	23
V. KUMARASWAMI . .	8	X. TEMMAPPA GUDDA .	1

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The output of ore from the district reached a maximum of 78,636 tons in 1909, since when it has gradually declined. During the five years 1909 to 1913 the average annual production was 66,782 tons. An output of 33,643 tons was recorded in 1914, since when production has ceased.

Chingleput.—Veins of manganese ore are said to have been detected in the laterite of the RED HILLS (13° 9′ : 80° 16′), and specimens were shown at the Madras Exhibition of 1857 (**F.** 1032).

Coimbatore.—Nicholson (**1302**, 23) notes the occurrence at VIRAPANELI (? VIRAPANDI, 11° 10′ 30″ : 77° 2′) of black sand containing manganese (**F.** 1032).

Ganjam.—Several superficial accumulations of manganese ore of small extent were discovered in 1902 by Mr. T. Chaudry in the Atagada and Kalikot Taluks. The ores occur either in connection with kodurite, an intrusive rock containing manganese garnet, or with garnet-rhodonite rock similar to that associated with the manganese ores of the Nagpur district. The following occurrences have been examined by Fermor :—

BOIRANI (19° 35′ : 84° 49′). Outcrop situated about half a mile to S. E. of village. A band of felspar rock underlying one of decomposed kodurite has been largely replaced by psilomelane, forming an ore bed which in one place reaches a thickness of 4½ feet. The ore is of very low grade. Analysis :—Mn=28·44 : Fe=19·70 : SiO_2=10·25 : P=0·712 per cent. (**F.** 1034).

Gravels composed of granules of manganese ore mixed with quartz and limonite, and a patch of manganese laterite, were found about half a mile to S. 10° E. These may indicate the presence of a band of manganiferous garnet rock below the surface (**F.** 1036).

GUDHIARI (19° 34′ : 84° 51′). Granules of manganese ore scattered through sandy soil at foot of hills to S. W. of village (**F.** 1036).

NAUTAN-BARAMPUR (19° 36′ : 85° 6′). Outcrops of garnet-rhodonite rock and khondalite (garnet-sillimanite rock) showing stains of manganese (**F.** 1036).

KALIKOT (19° 36′ : 85° 9′). Decomposed khondalite with small veins and stains of psilomelane (**F.** 1037).

RAMBHA (19° 31′ : 85° 9′). Gravel composed of fragments of limonite, decomposed quartzite, and a little manganese ore (**F.** 1037).

Kurnool.—Specimens of manganese ore from ROODRAR (RUDRAVARAM, 15° 14′ : 78° 40′) and impure braunite were exhibited at the Madras Exhibition of 1857.

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In the Kurnool Manual (**675**, 99) it is stated that manganese is to be found in NANDAVARAM (15° 22′ : 78° 20′), BANGANAPALLE (15° 19′ : 78° 17′), and NAGIREDDIPALLI (15° 9′ : 78° 35′), but no further particulars are given (**F.** 1038).

Madura.—Among the minerals collected by Muzzy (*see* Nelson, **1286**, 15, 30), specimens of wood opal striped with oxides of iron and manganese from PUDA-KUDI (?), and of several manganese-bearing minerals are mentioned (**F.** 1039).

Nellore.—Black sand containing iron and manganese is mentioned by Hunter (*see* Boswell, **174**, 7) as having been sent from the district to the Madras Exhibition of 1857 (**F.** 1040).

Nilgiri.—Newbold (**1294**—15, 45; —29, 214) mentions the discovery by Cullen and Benza of manganese ore in the Nilgiri hills.

At several places in OOTACAMUND (11° 24′ : 76° 47′) Fermor met with veinlets of soft black wad traversing lithomarge derived from the superficial decomposition of charnockite. The veins range up to half an inch or so in thickness (**F.** 1039).

Vizagapatam.—The manganese ore deposits of Vizagapatam appear to have first received attention in 1852, when two specimens, probably from KODUR, were analysed by Scott (**1597**), and found to contain 53·428 and 54·929 per cent. of manganese respectively. In a letter from Crozier quoted by Balfour (**69**—2, 238), it is said that the ore was obtainable in some quantity near CHIPURAPALLI (18° 18′ 30″ : 83° 38′), and that it was sold as a substitute for *surma* or antimony. Balfour (**69**—8, 1st Edn., 1183) also says that two tons of the mineral were sent by the Raja of Vizianagram to the Madras Exhibition of 1857. In 1886 King (**987**—33, 155) found that manganese ore, apparently associated with crystalline limestone, was being used for metalling the roads at a spot about 6 miles to the N. of Vizianagram and near RAMACHANDRAPURAM (? RAMBHADRAPURAM); and six years later the first manganese workings in India, on a commercial scale, were started at KODUR.

The manganese ores are found in association with a group of igneous rocks of peculiar composition, to which the name 'kodurite series' has been given by Fermor (*see* Holland, **859**—60, 22). These rocks are characterised by the presence of manganese lime garnets (spandite) and apatite, with or without orthoclase felspar, quartz, and manganese pyroxenes. In the coastal plains of Vizagapatam they are found interbanded with garnet-sillimanite schists and calc-

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gneisses (khondalites), in which there is reason to believe that the kodurites are intrusive. The varying composition of the rocks was originally attributed by Fermor to magmatic differentiation supposed to have taken place before the eruption of the magma; but more recently he has suggested (*see* Middlemiss, **1219**—31, 102) that the kodurites may be hybrid rocks, resulting from the intrusion of an igneous magma into a series of manganiferous and calcareous sediments, from which the manganese and lime of the garnets has been absorbed. If this can be confirmed, it will add support to Burton's suggested correlation (*see* Middlemiss, *l. c.*, 105, 132) of the calc-gneisses of the Central Provinces with those of Vizagapatam.

The ores themselves have been formed by the replacement of kaolinised felspar, or of the constituents of the kodurite, by manganese oxide, derived from the garnets and introduced in solution by percolating waters charged with carbonic acid. In some cases the manganese-garnet rock has been altered *in situ* by a similar process. The action is supposed to have taken place within the zone of weathering as defined by the kaolinisation of the felspars; and therefore the depth to which the ores may be expected to continue will depend on the maximum depth affected by weathering in former times. In some cases it is certainly more than 100 feet and may possibly extend to 500 feet.

The composition of the ores varies in different places. The principal varieties are psilomelane with subordinate amounts of pyrolusite, and psilomelane with scattered granules of braunite, according as they have been formed by the replacement of felspathic rocks or of the kodurite respectively. They vary in quality from ferruginous manganese ores, containing from 13 to 19 per cent. of iron, to manganese ores with from 43 to 50 per cent. of manganese. The proportion of phosphorus is often rather high, but that of silica is comparatively low (**F.** 243 *seq.*, 1045).

A description of the deposits being worked in 1896 has been given by Turner (**1815**). The deposits at GARBHAM were estimated by him to contain 1,500,000 tons of ore available above saturation level. These deposits have since yielded 736,192 tons of ore (to 1913 inclusive).

The following notes refer to the condition of the workings in 1905, and to the localities known to exist in 1907:—

KODUR (18° 16′ 30″ : 83° 36′ 30″). Here a manganiferous belt about 3 miles in length is worked at intervals. At either end of the belt (GARIVIDI and SANDANANDAPURAM), detrital ore is obtained

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from a number of shallow excavations. The principal working is situated near Kodur, about the centre of the belt, where a pit nearly 200 yards in length has been excavated in lithomargic clays, in which the ore occurs in irregular masses. These ore bodies are said to have a tendency to run together towards the bottom of the pit, and form a solid mass of ore. The total output from these quarries, from 1892 to 1913 inclusive, has amounted to 370,382 tons. Analysis :—Mn=47·11 : Fe=9·70 : SiO_2=3·15 : P=0·191 per cent.

Some ore has also been quarried from a pit at DEVADA, between Kodur and Sandanandapuram, where it occurred imbedded in lithomarge, as at Kodur (**F.** 1050).

SIVARAM (18° 16′ : 83° 39′). A certain quantity of ore, pyrolusite and psilomelane, has been quarried here (**F.** 1077).

PERAPI (18° 16′ : 83° 41′). Detrital deposits overlying banded quartz-felspar and spandite-felspar rock, partially converted into ore. Total output, 1900 to 1907 inclusive, 46,343 tons. The production for 1906 and 1907 included respectively 17,818 and 8,466 tons of ferruginous manganese ore. Analysis :—Mn=40·10 : Fe=13·20 : SiO_2=3·60 : P=0·207 per cent. (**F.** 1077).

Small quantities of ore have been raised by the Vizianagram Mining Company at ITAKERLAPILLI and MULAGAM, situated about 2 and 3 miles respectively to the S. of Perapi.

GOVINDAPURAM (18° 15′ 30″ : 83° 45′). Output, during 1906 and 1907, 2,045 tons of ferruginous manganese ore (**F.** 1081).

GARBHAM (18° 22′ : 83° 31′). The ore body exposed here, probably the largest in India, has a total length of 2,200 feet from E. to W., and possibly extends westwards for another 2,000 feet. The actual thickness in the middle of the deposit is 167 feet, of which 100 feet consists of ore, and it has been proved to continue to a depth of at least 100 feet. The main ore body has been formed by the alteration of bands of quartz-kodurite, interbedded with kaolinised quartz-felspar rock impregnated with wad, and occasionally containing masses of ore. The ores consist chiefly of a dull grey variety of psilomelane, with patches of mangan-magnetite, pyrolusite, and wad. They are usually of third grade quality and are often highly ferruginous. Analyses (manganese ore) :—Mn=45·39 : Fe=9·99 : SiO_2=4·43 : P=0·45 per cent.—(ferruginous manganese ore) :—Mn=35·43 : Fe=19·32 : SiO_2=6·90 : P=0·423 per cent. (**F.** 1081).

The average annual output from this deposit, from 1896 to 1913 inclusive, has amounted to 40,900 tons.

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KOTAKARRA (18° 22′ 30″ : 83° 33′). Excavations made to the W. and N. of the village show bands of kodurite and kaolinised quartz-felspar rock with layers of psilomelane. A few thousand tons of second grade ore are said to have been extracted from the pits (**F.** 1096).

GADASAM (18° 20′ 30″ : 83° 28′ 30″). Production during 1906 and 1907, 2,000 tons. Analysis :—Mn=46·87 : Fe=4·20 : SiO_2=4·55 : P=0·168 per cent. (**F.** 1098).

AVAGUDEM (18° 21′ : 83° 36′). A vertical ore band is exposed for about 625 yards, ranging up to 55 feet in width. The outcrop in 1905 was largely concealed by detrital ore. A large proportion of the ore seen *in situ* contains much chert and ochre. Analysis :—Mn=39·41 : Fe=13·30 : SiO_2=4·73 : P=0·440 per cent.

The deposit was worked in 1899 and again in 1906-07. Total output about 22,000 tons (**F.** 1098).

AITEMVALSA. GOTNANDI. BONDAPILLI. } About 3,000 tons of ore were raised in 1906-07 at these places, which are situated about 4 miles to the N. of CHIPURAPALLI (18° 18′ 30″ : 83° 38′)—(**F.** 1100).

GARRARAJU CHIPURUPALLI (18° 24′ : 83° 41′). The deposits here are said to be similar to those at Perapi. Total production, 1900 to 1907 inclusive, 17,797 tons. Analysis :—Mn=41·45 : Fe=11·70 : SiO_2=3·63 : P=0·298 per cent. (**F.** 1101).

PERUMALI (18° 26′ 30″ : 83° 38′). Total production, 1900 to 1907 inclusive, 5,121 tons, containing 40 to 46 per cent. of manganese (**F.** 1102).

RAMABHADRAPURAM (18° 30′ : 83° 20′ 30″). There are three sets of excavations here, lying within the village limits of SONPURAM, MAMIDIPILLI, and BANKURUVALSA, along an ore band about two-thirds of a mile in length, and probably about 100 feet in width. The deposits consist of bands of kodurite, quartz-kodurite, and felspar rock, intruded along the bedding planes of laminated felspathic quartzites. In 1905, none of the pits had reached a greater depth than 20 feet, but the continuance of the ore to depths of 67 and 100 feet had been proved by boring. The ore consists chiefly of psilomelane, often studded (especially in the Mamidipilli pits), with crystals of spandite. Pyrolusite is most abundant in the Bankuruvalsa pits. Production during 1906 and 1907, 2,712 tons. Analyses (Sonpuram and Bankuruvalsa) :—Mn=43·76 : Fe=11·35 : SiO_2=3·95 : P=0·33 per cent. (Mamidipilli) :—Mn=32·21 : Fe=15·20 : SiO_2=10·30 : P=0·482 per cent. (**F.** 1103).

Near TADURU (18° 25′ 30″ : 83° 16′) and CHINTELAVALSA (18° 25′ 30″ : 83° 20′), bands of manganese pyroxenite occur, associated

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with scapolite and biotite gneiss. No manganese ore was seen in connection with these deposits (**F.** 1110).

These two occurrences have been referred to (*see* Middlemiss' **1219**—31, 105) as affording evidence in favour of correlating a portion of the manganiferous sediments of the Central Provinces and their associated rocks with the manganese-pyroxenites, calc-gneisses and khondalite of Vizagapatam.

Deposits of manganese ore have been reported to occur at the following additional localities, and from some of them the outputs noted below were recorded in 1907 (**F.** 462, 1048) :—

BAIDAPILLI (?), 1,155 tons.
BAJUVALSA (?), 302 tons.
BATUVA (18° 20′ : 83° 41′), 1,485 tons.
BODDAM (18° 24′ : 83° 42′), 2,519 tons.
BUTHARAYAVALSA (18° 24′ : 83° 30′ 30″), 61 tons.
CHALLAPURAM (18° 20′ 30″ : 83° 31′), 440 tons.
CHINNA PALAVALSA (?), 27 tons.
CHINNA RANYAN (18° 21′ : 83° 31′), 2,329 tons.
CHIPURAPALLI (18° 18′ 30″ : 83° 38′), 1,337 tons.
DANNANAPETA (18° 11′ : 83° 35′), 846 tons.
DEVARAPILLI (18° 13′ : 83° 42′), 419 tons.
GADABAVALSA (18° 22′ : 83° 38′), 1,378 tons.
GUMADAM (18° 26′ : 83° 36′), 586 tons.
GUNPAM (18° 5′ : 83° 39′), 13 tons.
JADA (?), 890 tons.
KONDAPALEM (18° 16′ : 83° 37′), 40 tons.
KOTHAVALSA (17° 53′ 30″ : 83° 15′), 376 tons.
KOTTAPETA (?), 195 tons.
LAKSHMIPURAM (18° 16′ : 83° 40′), 3,672 tons.
LINGALAVALSA (18° 17′ : 83° 45′), 2,156 tons.
MUKKUNARASANNAPETA (?), 5 tons.
NAIDUVALSA (? 18° 40′ : 83° 18′), 54 tons.
NELLIMARLA (18° 11′ : 83° 31′), 3,942 tons.
NIMMALAVALSA (18° 18′ : 83° 44′ 30″), 754 tons.
RAVIVALSA (18° 18′ : 83° 39′), 21 tons.
REGATI (?), 4 tons.
SARVESWARAPURAM (?), 81 tons.
SIVANDHORAVALSA (18° 24′ : 83° 30′), 41 tons.
SOKARAPALEM (18° 19′ : 83° 46′), 264 tons.
VEDULLAVALSA (18° 21′ : 83° 35′), 1,048 tons.
VISWANADHAPURAM (18° 30′ 30″ : 83° 13′), 8 tons.
VIZIARAMPURAM (18° 12′ : 83° 31′), 2 tons.

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The output of manganese ore from the district reached a maximum in 1907, when it amounted to 136,169 tons. Since then it has declined considerably, the average annual production during the five years 1909 to 1913 having been 52,812 tons. In 1914 it fell to 26,375 tons. In 1915 an output of only 288 tons was recorded, and in 1916 of 2,755 tons.

MYSORE.

The occurrence of manganese ore in Mysore was mentioned by Ainslie (17, Vol. I, 538) in 1826, but without specifying the localities. Since the beginning of the present century, prospecting operations carried out by the officers of the State Geological Department have resulted in the discovery of a large number of deposits, some of which are of considerable commercial value; but in many cases the higher grade ores have apparently been worked out, for the production has declined from about 230,000 tons in the three years 1906 to 1908, to about 54,000 tons in the three years 1912 to 1914. The output in 1915 was 23,125 tons and in 1916, 24,911 tons.

The ores are in all cases of a superficial character, resembling the lateritoid ores of Sandur in their mode of origin and occurrence. They form masses, often of considerable size, in the lateritoid rock, and occur also as concretionary nodules and nests in the underlying lithomarges, decomposed phyllites, and quartzites, either in the form of psilomelane or pyrolusite. The depth of the deposits will probably be seldom found to exceed 50 feet, and is usually much less than this. The ores are usually of second or third grade quality, with a comparatively high percentage of iron, but with low silica and phosphorus. The deposits occur on the outcrops of the bands of Dharwar rocks which traverse the Mysore plateau in a general north to south direction (**F.** 1117).

Bangalore.—Specimens of banded iron and manganese ore, and of brown wad with fibrous manganese, were sent from this district to the Madras Exhibitions of 1855 and 1857, but the localities are not stated (**F.** 1119).

Chitaldroog.—SADARHALLI (14° 8′ : 76° 15′). A deposit of lateritoid rock, forming a capping to a hill situated about a mile and a half to E. N. E. of the village. The thickness varies from 2 to 20 feet. Psilomelane is found in the lateritoid rock and to a certain extent in the underlying lithomarge, and pyrolusite in decomposed bands of quartzite. The amount of ore available may be about 10,000 tons. In one place there is a deposit of pisolitic manganese and iron ore resembling true laterite. The ores tend to be high in silica (**F.** 1122).

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DOD KITTADHALLI (13° 56′ 30″ : 76° 26′). Smeeth (**1652**—2, 42) has recorded the occurrence of manganiferous hematite at this locality (**F.** 1124).

MADADKERE (13° 53′ 30″ : 76° 27′). Bands of soft earthy manganese ore, associated with hematite quartzite and earthy ferruginous limestone, were found by Sambasiva Iyer (**1548**—9) on a line of low hills to the E. of the village. A specimen from an outcrop 6 feet in width contained 34 per cent. of manganese. Extensive areas are also said to be covered with a deposit of dark manganiferous earth yielding 9 per cent. of manganous oxide (**F.** 1124).

NIRGUDDA HILLS (13° 58′ : 76° 29′). In one of these hills, called Munisinganagudda, workable bodies of manganese ore are said to have been found (**F.** 1125).

IPLARA HILLS (13° 55′ : 76° 24′). Loose pieces of manganese ore, some of good quality, mixed with fragments of manganiferous iron ore, were found by Smeeth (**1652**—3, 167; —7, 24) on these hills. The occurrence of manganese ore in ferruginous quartzites and schists on Bodimaradi hill in this neighbourhood has also been recorded by Smeeth (**1652**—8, 17)—(**F.** 1125).

Particulars of prospecting operations carried out in 1907 have been given by Balaji Rao (**68**—3). The ores are said to be of low grade, and are usually found at depths of 8 to 10 feet from the surface.

The output of ore from this district, during the years 1906 to 1910, amounted to 15,511 tons. No returns of production have been recorded since the latter year.

Kadur.—UBRANI (13° 51′ : 75° 58′ 30″). Slater (**1649**—5, 26) mentions having found lumps of manganese ore on the road leading westwards from Ubrani to Gangur, in the Shimoga district (**F.** 1126).

KANNIKALMATTI HILL (13° 48′ : 75° 53′). In the map attached to Slater's report cited above (Pl. II), manganese and iron ores are shown as occurring on the crest of the hill. Large deposits of detrital ore have also been found at the base of the hill on the N. W. side, lying both in the Kadur and Shimoga districts. The deposits show nodules and concretions of psilomelane in a matrix of clay, as much as 25 feet deep in one place (**F.** 1126).

An output of 3,307 tons of ore is recorded in the year 1909 from this district.

Shimoga.—Manganese ore from this district was shown at the Madras Exhibition of 1855, and small quantities were afterwards

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employed at the Madras School of Art for colouring pottery and glass; but it was not until the district was geologically surveyed by Slater (**1649**—1; 3—7) in 1901—1907 that the existence of deposits of commercial value was discovered.

The rocks associated with the ores are phyllites, dolomites, and quartzites comprised in the Dharwar-Shimoga band of the Dharwar series. The ores occur as lateritoid masses, resting upon the outcrops of these rocks, especially of the decomposed phyllites and quartzites, and are usually found on the tops of the hills, forming cappings with a nearly horizontal upper surface. In mode of origin they resemble the lateritoid ores of Sandur in Bellary, and consist of the same varieties, psilomelane, wad, and pyrolusite. Pisolitic ores, composed of spherules of psilomelane set in a matrix of wad or of lead-like psilomelane, are not uncommonly found. The ores are usually of second or third grade quality, containing on the average about 47 per cent. of manganese. They contain a comparatively high percentage of iron, but that of silica and phosphorus is very low (**F.** 1129).

The localities at which the deposits occur are arranged in five groups by Fermor:—

I. SHIKARPUR group:—

The group comprises five deposits, extending in a line eastwards from ITIGEHALLI (14° 14′ : 75° 28′ 30″) through VADDERPUR, HOSUR and KAGINELLI to BALLUR (14° 15′ : 75° 34′ 30″). No information with regard to the mode of occurrence or extent of the deposits has been published (**F.** 1133).

II. AYANUR group:—

TUPPUR (14° 5′ : 75° 22′). A specimen of dull grey psilomelane from this deposit, situated to S. W. of the village, contained 32·10 per cent. of manganese and 28·11 per cent. of iron (**F.** 1134).

KUMSI (14° 3′ : 75° 27′). These deposits are situated on the northern slope of the hills about 3½ miles to N. by W. of the village, and are the most extensive in the district, measuring about 1,000 feet in length, and 32 feet in width. In 1907 the workings had reached a depth of 25 feet without signs of serious deterioration in the ore, and the total quantity available within a maximum depth of 50 feet was estimated by Fermor at about 300,000 tons. The deposits mainly consist of large concretionary boulders of psilomelane, with comparatively little interstitial clay, but in places they appear to be bedded. The quality of the ores is variable, owing to the replacement of manganese by iron. The mean of 14 analyses showed:—Mn=46·68: Fe=10·86: SiO_2=1·34 per cent. (**F.** 1135).

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The deposits are worked by the New Mysore Manganese Co., and produced about 160,000 tons of ore during the three years, 1906 to 1908.

Bikonhalli (14° 2′ : 75° 39′). The ores occur in lateritoid cappings on a hill situated nearly 2 miles to W. S. W. of the village. They are developed in a very irregular manner, forming a network in partly replaced phyllite and quartzite, and probably do not continue to a greater depth than 50 feet. The chief ores are pyrolusite and manganiferous limonite. Analysis (average sample):—Mn= 45·23 : Fe=10·36 : P=0·053 per cent. (**F.** 1139).

Aladhalli (14° 2′ : 75° 40′). Two outcrops of ore are said to occur on the side of a hill to the S. of the village (**F.** 1142).

III. Shankargudda group :—

Shankargudda (13° 55′ : 75° 28′). Deposits of pisolitic manganese ore were found by Slater (**1649**—4, 54) at three places on the crest of the range to the S. E. and S. S. E. of Shankargudda peak. The deposits were being worked in 1907 by the New Mysore Manganese Co. Hand specimens of the ore yielded from 40 to 55 per cent. of manganese, 4 to 17 per cent. of iron, and 0·06 per cent. of phosphorus (**F.** 1143).

Venkataramaiya (**1838**—3, 157) has given details of the mines worked by the Workington Iron and Steel Co. in these hills.

Tirandur (? Todur, 13° 43′ : 75° 27′). Slater (*l. c.*) records the find of a loose block of manganese ore 3 furlongs to E. of the village, which is situated between Mandagadde and Malur, about 14 miles to the S. of Shankargudda.

IV. Channagiri group :—

Sulekere (14° 8′ : 75° 56′). A deposit is said to exist on a hill at the western end of Sulekere tank (**F.** 1145).

Gaddikalmatti (13° 57′ : 75° 54′). The deposit formed a capping to a small hill at the road side, 46½ miles from Chitaldroog, but has been largely removed by excavation. A considerable quantity of detrital ore was seen on the slopes of the hill (**F.** 1145).

Buddamatti peak (13° 57′ : 75° 55′). Situated a little E. of the road about 45¾ miles from Chitaldroog. An outcrop of lateritoid iron ore is exposed, by the side of which is an excavation showing yellow ochre mixed with psilomelane and containing large patches of pyrolusite (**F.** 1146).

Hoshalli (13° 58′ : 75° 55′). Lateritoid deposits occur in a group of four hills lying to S. S. E. of the village. On the most southerly of these,—called Treasury hill in consequence of a discovery of fine specimens of radiate pyrolusite lining cavities,—a trench sec-

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tion exposed about 44 feet of alternating layers of psilomelane and yellow ochre. The psilomelane is often intimately associated with a peculiar horny variety of hematite (**F.** 1146).

V. SHIDDARHALLI group :—

GANGUR (13° 51′ : 75° 53′ 30″). Slater (**1649**—5, 24) records the occurrence of lateritic (lateritoid) deposits with hematite and pisolitic manganese ore over an area of 2 to 3 square miles on the crest of a ridge lying to N. N. E. of the village. About 1,000 tons of ore are said to have been raised in 1907 (**F.** 1148).

KANJIGANAGUTTI
URUMANJANMATTI.
NAGALAGUTTI } These three deposits are situated within a mile to N. and N. E. of Shiddarhalli village (13° 48′ : 75° 52′). The first shows clearly the passage by replacement of argillaceous rocks,—slates or phyllites—into lateritoid containing wad, psilomelane, and hematite. The second exhibits the impregnation and replacement of quartzites by iron and manganese oxides. The third deposit, lying at the base of Urumanjanmatti hill on the E. side, consists of detrital ore probably derived from the summit of the hill by denudation (**F.** 1149).

The production of manganese ore in this district has greatly declined since the year 1907, when a maximum output of 97,091 tons was recorded. The average for the five years 1909 to 1913 was 26,087 tons. In 1914 the district produced 18,055 tons.

Tumkur.—The manganese deposits of this district are all situated within a radius of 12 miles to the E. and S. E. of CHIKNAYAKANHALLI (13° 25′ : 76° 41′), and lie in the southern extension of the Chitaldroog or Dambal-Chiknayakanhalli band of Dharwar rocks. The ores are of poor quality, probably containing on the average not more than 42 to 45 per cent. of manganese. The deposits are divided by Fermor into three groups, only one of which has been described :—

CHIKNAYAKANHALLI group. { HONNEBAGI (13° 24′ : 76° 41′ 30″).
HOSHALLI (13° 26′ : 76° 42′).

KONDLI group. { MAVINHALLI (13° 22′ : 76° 47′).
KONDLI (2 deposits)—(13° 22′ : 76° 48′).
SHIVASANDRA (13° 21′ : 76° 47′ 30″).

KAREKUCHI group :—

SONDENHALLI (13° 22′ : 76° 43′). Yellow ochre with patches of pyrolusite and limonite is exposed in pits, also lateritoid outcrops with psilomelane and pyrolusite (**F.** 1153).

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MUSKONDLI (13° 21′ 30″ : 76° 47′). A trench shows wad and ochre with residual patches of quartzite partly converted into cavernous pyrolusite and limonite (**F.** 1153).

KAREKURCHI (13° 21′ : 76° 46′). Outcrop of lateritoid rock on elevated ground about half a mile to E. 10° N. of the village. Patches of psilomelane and pyrolusite, sometimes of good quality and considerable size, are found irregularly distributed through a mixture of ochre, lithomarge, and wad (**F.** 1153).

HATTYAL (13° 20′ : 76° 45′). Pyrolusite and wad occur as patches and bands respectively in white lithomarges and 'sandstones,' (probably decomposed quartzites) (**F.** 1154).

HARENHALLI (13° 19′ : 76° 46′ 30″). The deposit here is similar to that at Karekurchi.

During the years 1906 to 1908, the district produced 25,101 tons of ore. Since then no output has been recorded.

NORTH-WEST FRONTIER PROVINCE.

Kohat.—A bed of flattened concretionary nodules, consisting of limestone impregnated and partly replaced by manganese oxide was found in 1906 by Amin Khan, a student at the Cawnpore Agricultural College, on the western slopes of TAJUT HILL (TAGHOOT SIR, 33° 31′ : 71° 12′), two miles to the S. of Ibrahim Zai (**F.** 1155).

PUNJAB.

Jhang.—KIRANA HILLS (31° 58′ : 72° 45′). Fleming (**591**—5, 446; —8, 94) states that he found small specimens of pyrolusite filling cavities in 'sandstone' (slates); but Heron, who examined these hills in 1909 (*see* Hayden, **793**—24, 71), could find only traces of the mineral (**F.** 1156).

Kangra.—Crystals of marcelline, an impure form of braunite, have been reported by Marcadieu (**1168**—1, 4) to occur at a spot 4 miles to the N. W. of DHARMSALA (32° 14′ : 76° 23′). They are said to be found in a ferruginous and manganiferous limestone.

Calvert (**265**—2, 11) mentions the occurrence of a small lode of pyrolusite with bismuth at THIRRI (SIRHI, 31° 50′ : 77° 14′), on the borders of Kulu (**F.** 1156).

Patiala.—Bose (**173**—21, 58) states that extensive deposits of limestone and shale impregnated with manganese oxide occur in the neighbourhood of GOELA, DURGA-KA-NANGAL (27° 53′ : 76° 6′), etc., in the Narnaul district. Specimens consist of amphibolitic lime-

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stone partly replaced by manganese, but not sufficiently so to render the ore commercially valuable (**F.** 1156).

RAJPUTANA.

Ajmer.—Specimens of stalactitic psilomelane with limonite are preserved in the Geological Survey Museum (Mallet, **1159**—50, 61). Pyrolusite has been found near KHARWA (26° 12′ : 74° 30′) by R. D. Kanga (**F.** 1157).

Alwar.—The iron ore of BHANGARH (27° 5′ 30″ : 76° 21′) is reported by Hacket (**730**—2, 91) to contain 12·7 per cent. of manganese (**F.** 1157).

Banswara.—Deposits of manganese ore have been found by Messrs. Kiddle, Reeve and Co. of Bombay at ITALA (23° 17′ 30″ : 74° 22′) and the villages of SAGWA, GHATIA, KHUNDA, SIVONIA, and GARADIA, all situated within a few miles to the N. W. of Itala. The ore at Khunda and Sivonia is said to be of good quality. Specimens of pyrolusite from these deposits have been found to be exceptionally pure, containing 61·68 per cent. of manganese (**F.** 1157).

Bundi.—Small veins of oxide of manganese occur in fault rock near DATUNDA (25° 27′ : 75° 30′). According to Hacket (*see* Ball, 71—45, 331), these deposits have not been worked (**F.** 1158).

Marwar (Jodhpur).—A specimen sent to the Geological Survey Office, obtained by Major Hughes near HARIPUR (26° 1′ : 74° 5′), proved to be partly altered rhodonite (**F.** 1158).

Mewar (Udaipur).—Mallet (**1159**—50, 61) mentions specimens of psilomelane with limonite, collected at GANGAR (25° 3′ : 74° 40′) by Hacket (**F.** 676).

UNITED PROVINCES.

Mirzapur.—The only known instance of the occurrence of manganese in these provinces is recorded by Mallet (**1159**—50, 84). He says that a specimen of rhodonite was given to him by a *lohari*, or native iron-smelter, who found it a foot or two beneath the surface in the southern part of the Mirzapur district. The precise locality is not mentioned (**F.** 1158).

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MARBLE *see under* **BUILDING MATERIALS.**

MELANTERITE *see* **SULPHATES—IRON.**

MERCURY.

The evidence in favour of the occurrence of mercury in India or the adjacent countries is defective and unsatisfactory, since it depends almost entirely on single statements which do not appear to have been subsequently investigated. Those accounts which do not owe their origin to the accidental breaking of a barometer tube, or perhaps the escape of mercury from a dispensary, refer, with the exception of Aden, to localities which are difficult of access.

ADEN.

Malcolmson (**1158**—11) gives a circumstantial account of the discovery of small globules of mercury in a cellular mass of lava, which was found at a depth of 15 ft. at a spot about 200 yards from the beach on a road then (1843) being made through the centre of the new cantonment (**B.** 172).

AFGHANISTAN.

Hutton (**900**—8, 600) states that mercury is said to be dug out of the ground at Pir Kisri (? 31° 18′ : 62° 18′), in the district of Gurmsael or Garmsir (**B.** 170).

ANDAMAN ISLANDS.

Ball (**71**—11, 238) quotes a statement made by Mahommedan travellers in the ninth century, to the effect that a party of sailors, having landed on an island supposed to be one of the Andamans, and having lit a fire, saw a metal resembling molten silver run from the heated rock. They are said to have brought away a quantity of the ore, but were compelled by a storm to throw it overboard; and the locality, though carefully sought for, was never again identified.

Another account by Hamilton (**744**, Vol. II, 66; quoted by Mouat, **1263**—3, 12) states that a slave from the Little Andaman, who had been permitted to revisit his country, brought away a quantity of quick-silver, which he reported to be abundant. Ball appears to consider it possible that cinnabar may occur in connection with the intrusions of serpentine known to exist in the islands (**B.** 171).

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BURMA.

It has been asserted, on what appeared to be good authority, that cinnabar has been found in the Shan States; but it is probable that the brilliant red clay derived from the dolomitic limestones of the plateau has been mistaken for this mineral (La Touche, **1031**—45, 379).

TIBET.

Saunders (**1559**—1, 96) mentions the occurrence of cinnabar in Tibet, but does not specify the locality. According to Gutzlaff (**728**-2, 202), it is said to be found at BATANG (30° 0′; 99° 30′).

MICA.

A monograph on Indian mica, in which the mineralogical and chemical characters of this substance, its geological occurrence and geographical distribution, and the methods of working the deposits were fully discussed, was published by Holland (**859**—37) in 1902. From this work the notes given below are mainly extracted, references to it being denoted by the letter **H.**

Although mica is one of the most common constituents of schists, granites, and other crystalline rocks of metamorphic or igneous origin, it occurs as a commercially valuable product only in the coarser forms of pegmatite, which are believed to have solidified at considerable depths in the earth's crust. It is therefore restricted to areas which have undergone long continued denudation; and, on account of the susceptibility of the mineral to deformation by earth movements, to those which have not been subjected to violent crust disturbances since the period of intrusion of the pegmatites. These conditions are fulfilled by the Indian peninsular region, which has enjoyed a period of quiescence since at least the lower Palæozoic age; and accordingly the most valuable deposits of mica are to be found in this area.

The pegmatites commonly occur in the form of sheets intruded along, but sometimes cutting across, the foliation or bedding planes of mica schists, quartzites, etc., of the upper Archæan group, or occasionally forming lenticular masses and bosses. The mica is of the variety known as muscovite.

The average annual production of mica in India, during the five years 1909 to 1913, amounted to 35,749 cwt., or about 65 per cent. of the world's production during the same period. In 1914 the output was 40,506 cwt., but in 1915 it fell to 27,140 cwt.

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BIHAR AND ORISSA.

The mica deposits of this province are distributed along a belt of schists and associated gneissose granite (dome-gneiss), about 12 miles in width, forming a scarped border to the gneissic plateau of northern Hazaribagh, and extending from Bendi in that district through the south-eastern portion of Gaya to the neighbourhood of Nawadih or Jha-Jha in Monghyr, a distance of about 60 miles. Up to the year 1902, some 250 so-called 'mines' had been opened along this belt. These workings were of the most primitive and wasteful description, being either trenches not more than 20 to 25 ft. deep, or tortuous holes following the mica from 'book' to 'book,' in which no adequate provision was made for dealing with water or waste material, or for ventilation. They were described by Buchanan-Hamilton (*see* Martin, **1181**, Vol. I, 244) in 1838, and later by McClelland (**1117**—33, 20), Sherwill (**1625**—7), and Mallet (**1159**—7, 41).

About the year 1898, a regular system of mining by means of shafts and cross-cuts was adopted by the Indian Mica Co. at Lalki, near Bendi, under the direction of Mervyn Smith (**1654**—6), and has been gradually extended to other localities. The advantages of employing a systematic plan of stoping, which is rendered possible by the occurrence of the mica-bearing pegmatites in more or less regular sheets, has been pointed out by Holland (**H.** 80).

During the years 1904 to 1914, seven mining leases, covering a total area of 2,072 acres, were granted in the Gaya district, and 71 leases, covering 11,902 acres, in Hazaribagh.

The principal mining centres enumerated by Holland (**H.** 45) are :—

Gaya Dabur (24° 35′ 30″ : 85° 36′).
Rajauli (24° 39′ : 85° 33′ 30″). According to Sherwill (*l. c.*), writing in 1851, these mines produced about 14 tons of mica annually, yielding about 23 million plates of 9 ins. square.

Hazaribagh Bendi (24° 31′ : 85° 28′ 30″).
Charki (24° 34′ 30″ : 85° 53′).
Dhab (24° 35′ : 85° 50′).
Domchanch (24° 28′ 30″ : 85° 45′).
Gawan (24° 37′ : 85° 58′ 30″).
Gharanji (24° 33′ 30″ : 86° 12′).
Kodarma (24° 28′ : 85° 39′). A full description of the mode of occurrence of mica at this locality and in the neighbourhood, and of the mining methods employed, has been given by

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Dixon (**490**). A systematic plan of working the deposits was introduced about the year 1907, and has been described by Dickson (**485**—1; —2). The dip of the pegmatite sheet having been ascertained by following it to a depth of about 100 ft., and the strike by an exploratory drift following the hanging wall, the bodies of mica-bearing pegmatite met with are worked out by a series of transverse cuts, the spaces left being filled in with waste rock. Overhand stoping is not advocated by the author, on account of the danger from falls of the roof, where many of the miners employed are of necessity practically untrained.

TISRI (24° 35′ : 86° 7′).

Monghyr MAHAISRI (24° 42′ : 86° 19′).
NAWADIH or JHA-JHA (24° 47′ : 86° 26′ 30″).

The average annual output from the Bihar mica belt, during the five years 1909 to 1913, amounted to 25,579 cwt. In 1914 the production was 33,275 cwt., and in 1915, 22,195 cwt.

Mayurbhanj.—Bose (**173**—20, 171) has recorded the occurrence of promising veins of mica-bearing pegmatite, exposed at intervals along the SANKRAI R. in the neighbourhood of JAMGODIA (22° 6′ : 86° 34′). Plates measuring more than 8 sq. ins. were obtained from the outcrop. Pieces of smaller dimensions were observed near SIRSA (22° 14′ 30″ : 86° 42′ 30″) and BANGARPOSI (22° 9′ : 86° 35′); also about TIRING (? TIRINGDIH, 22° 31′ : 86° 8′) and RAIBEDI (22° 27′ 30″ : 86° 4′), in the Bamanghati sub-division of the State.

BOMBAY.

Rewa Kantha (Chota Udaipur).—Mica deposits have been reported to occur in the GABADIA HILLS, within 3 miles of the town of CHOTA UDAIPUR (22° 18′ : 74° 4′), but have not received expert examination (**H.** 53).

(Narukot).—Mica occurs in abundance, according to Fulljames (**629**—9, 101), on a hill called DHOLA SODUR, lying to the S. W. of JAMBHUGODA (22° 22′ : 73° 48′), but is found only in small fragments (**H.** 53).

BURMA.

Small quantities of mica have been obtained near YE-NYA-U, in the neighbourhood of THABEIKKYIN (22° 53′ : 96° 1′) in the Ruby Mines district; and its occurrence has been reported from several

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places near the INDAW R., flowing into the INDAWGYI LAKE (25° 15′ : 96° 25′), in the Myitkyina district (**H.** 54).

CENTRAL INDIA AGENCY.

Jhabua.—Mica has been reported to occur at KANAS (22° 31′ 30″ : 74° 36′) and RANAPUR (22° 39′ : 74° 35′), but on investigation the deposits were found to be of no value (*see* Holland, **859**—66, 48).

Rewah.—Sheets of mica, 4 to 5 ins. square, have been found at BARDGHATTA (23° 58′ : 82° 47′) in Singrauli. The rocks of this area resemble and appear to form a continuation of those constituting the Bihar mica belt, and are traversed by numerous intrusions of schorlaceous pegmatite (**H.** 54).

CENTRAL PROVINCES.

Balaghat.—Grant (**690,** 18) mentions old mica workings in the Baihar sub-division of the district. As the result of exploratory work, some mica was raised at CHITADONGRI (22° 8′ : 80° 31′) and BAMNI (22° 8′ : 80° 41′ 30″) in 1869, but apparently in sizes not larger than 8 sq. inches (**H.** 55).

A mining lease in this district, covering 171 acres, was issued in 1912 to Messrs. Lalbihari and Ramcharan, but no output has yet been recorded.

Bastar.—Plates of muscovite measuring 4 to 5 ins. across were found in 1899 by Bose in a coarse granitoid rock exposed in the BAORDHIG R. to the S. of JUNGANI (19° 45′ : 81° 43′). The specimens obtained were from the weathered outcrop, and were damaged by gliding planes (**H.** 55).

Bilaspur.—A certain amount of prospecting has been undertaken at KOMOCHOKI (22° 36′ 30″ : 82° 7′), where there are numerous pegmatite veins, but the mica obtained did not exceed 2 ins. square, and was of second-rate quality (**H.** 55).

MADRAS.

Coimbatore.—Muscovite occurs in coarse corundum-bearing felspar rocks near KARATAPALAIYAM (11° 3′ : 77° 35′), and in numerous pegmatite veins in the same neighbourhood and near PADIYUR (11° 3′ 30″ : 77° 33′). An attempt to work the deposits proved unsuccessful, as the mica is not sufficiently large or abundant to pay for mining the mica alone (**H.** 58).

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In the year 1913, four mining leases for mica, covering a total area of 238 acres, were issued in this district, but no statistics of output have yet been recorded.

Coorg.—Muscovite of good quality has been found near POLLIBETTA (12° 14′ : 76° 0′), in pegmatite veins traversing a group of schists similar in character and origin to those associated with the mica deposits of Bihar and Nellore. The plates obtained were in one case large enough to be cut into rectangles from 5×7 ins. to 12×14 ins. in size, and were favourably reported on in London, but no development of this area has apparently taken place (**H.** 55).

Ganjam.—Veins of coarse pegmatite, occasionally charged with mica, were found by Smith (**1657**—3, 164) at the villages of GORADANDI, BODIAMBA, and JILLUNDI, situated a few miles to the S. W. of RUSSELKONDA (19° 55′ 30″ : 84° 39′). The occurrence at Jillundi was the most promising, plates of mica of 5 ins. diameter being obtained at a depth of 3 to 6 ft.; but at a depth of 8 ft. the mica disappeared. It was of poor quality and very frequently penetrated by crystals of quartz.

Mica of poor quality has been reported to occur at SISUNDA (20° 3′ : 84° 46′ 30″), and at a locality 4 miles to N. and 2 miles to E. of the RAYAGADA and GUMA HILLS (18° 59′ : 84° 5′), in the Parlakimidi estate (**H.** 58).

Malabar (Wynaad).—Very promising veins of mica-bearing pegmatite have been discovered at the following localities:—

CHERAMBADI (11° 32′ : 76° 22′).
DEVALA (11° 28′ : 76° 26′).
GUDALUR (11° 30′ : 76° 33′).
NELLAKOTA (11° 34′ 30″ : 76° 27′).
PANDALUR (11° 29′ : 76° 24′).

The 'books' of mica in this area usually occur in the centre of the pegmatite veins, with dyke-like masses of quartz on one side, and almost quartz-free felspar on the other. At Cherambadi, the only place where mining had been carried on in 1902, the mica, according to Hayden (**793**—5, 56), was ruby-coloured and of excellent quality, occurring in crystals up to 2 ft. in diameter. The mica is remarkably free from accessory minerals, and the country rock is usually a soft biotite gneiss, which is easily worked (**H.** 65).

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Nellore.—Mica mining in the Nellore district has attained considerable importance since the first mine was opened in 1889 at Inikurti. During the years 1904 to 1914 inclusive, the mining leases issued numbered 166, covering a total area of more than 11,000 acres. The mode of occurrence of the principal mica deposits have been described by Thompson (**1772**), Krishnaiya (**1014**), and Dixon (**490**); and the geology of the region by T. L. Walker (*see* Holland **859**—37, 59).

The plains of Nellore, lying between the Veligonda range of hills and the Bay of Bengal and between the 14th and 15th parallels of latitude, are occupied by a complex series of gneisses and schists, striking generally from N. N. W. to S. S. E. The eastern half of this schistose area is traversed by numerous sheets and lenses of coarse pegmatite, consisting of mica, felspar, and quartz. Krishnaiya divides the mica belt into four zones, named respectively after the towns of GUDUR (14° 9′ : 79° 54′ 30″), RAPUR (14° 12′ : 79° 36′), ATMAKUR (14° 37′ : 79° 41′), and KAVALI (14° 54′ 30″ : 80° 3′). The principal mines—those of 'Pallimitta' and 'Tellabodu' near SAIDAPURAM (14° 11′ : 79° 48′); KALICHEDU (14° 18′ : 79° 48′); INIKURTI (14° 20′ 30″ : 79° 46′ 30″); and 'Lakshminarayana' near CHAGANUM (14° 12′ 30″ : 79° 44′ 30″), are situated on lenticular masses or bosses of pegmatite. 'Sankara' mine, 3 miles to the W. of GRIDDALUR (14° 16′ : 79° 50′) lies on a vein over 100 ft. in length and 40 ft. wide. These are all in the Rapur zone. A vein 15 ft. thick, in chlorite schist, is worked at MANGALPUR (?) in the Gudur zone; and a mine named 'Rappala Dibba' in the Atmakur zone is worked in a vein about 150 ft. long and 40 ft. wide. In 1910 the Inikurti deposit had been quarried to a depth of 150 ft.; and in this and some of the other mines levels were being driven underground, but only six were equipped with pumping machinery.

The mica obtained is usually of a greenish colour, due to a trace of chromium, but ruby-coloured mica is occasionally found. Much of it is stained with oxide of iron. The production reached a maximum in the year 1906, when it amounted to 24,420 cwt. Since that year it has declined, the average annual output for the quinquennial period 1909 to 1913 being 8,868 cwt., as against 12,931 cwt. in the preceding five years. In 1914 the output fell to 5,989 cwt., and in 1915 there was a further decline to 3,894 cwt.

Salem.—Plates of brownish muscovite, measuring a foot across the cleavage planes, were obtained by Middlemiss near IDDAPADI (11° 35′ : 77° 53′ 30″), and mining on a small scale has been attempted at CHINNAMALI, near that town, and at ARASIRAMANI (11° 33′ 30″ : 77°

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51′). The pegmatites of this area are instrusive in granites, and are not likely, in Holland's opinion, to contain mica in paying quantity (**H.** 66).

Travancore.—Amber-coloured phlogopite, biotite and muscovite occur in the Eraniel Taluk, according to Masillamani (**298**, 21, 34; **1183**, 3), in veins of coarse pegmatite, but attempts to work the deposits have proved unsuccessful. The principal localities mentioned are TIPPERAMALAI (?) and TOLICODE (8° 14′ : 77° 16′).

In the northern division of the State, veins of mica were observed by Chacko (**297**—1, 9) at KURINJI (9° 49′ : 76° 44′). An outcrop 50 ft. long by 20 ft. broad was exposed, but the mica was of poor quality.

Vizagapatam.—Phlogopite in even sheets, 4 to 5 ins. in diameter, exhibiting the phenomenon known as *asterism*, has been found on the Waltair estate (**H.** 23,67).

MYSORE.

Hassan.—According to Sambasiva Iyer (**1548**—10, 60), mica in plates up to 6×6 ins. in size is said to occur in a watercourse draining a tank to the E. of CHIKKANHALLI (12° 46′ 30″ : 76° 10′).

Kadur.—Sampat Iyengar (**1549**—11, 69) records the occurrence of mica in plates up to 10×8 ins. in size in pegmatite veins intrusive in gneiss near KIKRI (13° 25′ : 75° 20′). The mica is said to be confined to a depth of 10 ft. from the surface. About 540 cwt. had been collected by the end of March 1911.

Mysore.—Primrose (**1431**—2, 52; —8, 220) mentions the occurrence of mica in plates of fairly large size in veins of coarse pegmatite near KUPYA (12° 28′ 30″ : 76° 19′) in the Yedatore Taluk, and at UNDIVADI (12° 24′ : 76° 37′).

Mica has been worked, according to Wetherell (**1915**—1, 101), in a vein of coarse pegmatite near VIRASIMUDRA (VADESAMUDRA, 12° 33′ : 76° 47′) to the N. E. of French Rocks.

A list of the localities at which mica has been observed by the State geologists in Mysore is quoted by Holland (**H.** 68).

Since the year 1911 a small annual output of mica has been recorded from the Mysore State. The amount raised to the end of the year 1915 was about 150 cwt.

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PUNJAB.

Gurgaon.—Mica in large plates is said to be obtainable at MAHAN TI (?) and BHUNSI (28° 21′ : 77° 7′). According to Baden-Powell (**60**—1, Vol. I, 42), a fine specimen from one of these localities was shown at the Lahore Exhibition of 1864 (**H.** 68).

Kangra (Bhabeh).—Crystals of brown muscovite, measuring up to 5 or 6 ins. in diameter, and 1 or 2 ins. thick, were observed by Mallet (**1159**—1, 169) in the granite at WANGTU BRIDGE (31° 32′ : 78° 4′) on the Sutlej R. (**H.** 69).

(Kulu).—Plates of mica of marketable size have been obtained in the upper Chandra valley, especially near the HAMTA PASS (32° 16′: 77° 26′), and in the upper reaches of the Parbati valley; but they have usually been deformed by earth movements. They occur in contemporaneous veins in gneissose granite, and in veins of pegmatite traversing the associated schists (**H.** 69).

Patiala.—Bose (**173**—21, 58) mentions the occurrence of muscovite in lenticular veins of coarse grained granite intrusive in Arvali rocks in the Narnaul tehsil. The localities specially mentioned are GATASHER (27° 58′ : 76° 6′), SARAILI, MUSMUTA, and PANCHNAUTA (27° 53′ 30″ : 76° 4′). 'Books' of mica up to 9×6 ins. in size were obtained.

RAJPUTANA.

Ajmer-Merwara.—Irvine (**910**—1, 165) states that mica in large plates occurs abundantly in the district. It has been found near AJMER (26° 27′ : 74° 41′), BHINAI (26° 3′ : 74° 50′), and TALANA (26° 19′ 30″ : 74° 55′); and in Merwara at KALINJAR (26° 0′ : 74° 19′ 30″), RAWATMAL (25° 54′ 30″ : 74° 13′ 30″), and SULIAKHERA (25° 49′ : 74° 8′ 30″). No extensive mining has been carried out in the district (**H.** 70).

Jaipur.—A plate of mica measuring $10\frac{1}{2}\times5\frac{1}{2}$ inches was sent to the Colonial and Indian Exhibition of 1886. In quality it was inferior to Hazaribagh mica (**H.** 70).

Kishangarh.—Weathered samples of mica from this State were reported on by Dunstan (**514**—2) in 1900 and pronounced to be worthless, on account of the striated and cracked condition of the sheets. Several outcrops of coarse pegmatite, traversing gneissose granite, were subsequently examined by Vredenburg. The most

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promising veins were seen about a mile to the S. W. of DADIA (26° 25′ : 75° 2′); about a mile to the N. of NEAGAON (26° 5′ 30″ : 75° 5′); and about 2 miles from SARWAR (26° 4′ : 75° 4′) on the northern side of the Nasirabad road. These deposits do not appear to have received further attention (**H.** 70).

Sirohi.—Plates of good muscovite, measuring 5 or 6 ins. square, have been obtained near ROHIRA (24° 37′ : 73° 1′ 30″) by Major Hughes (**H.** 71).

Tonk.—Muscovite of good quality, in plates measuring 5 to 6 ins. across, has been found at several places in the CHATTARBHAJ HILLS, to the N. E. of TONK (26° 10′ : 75° 51′), and sent to the Geological Survey Museum (**H.** 71).

A certain quantity of mica has been mined annually in Rajputana since the year 1904. The average annual output, for the five years 1909 to 1913, was 1,284 cwt., as against 4,664 cwt. in the previous quinquennial period. The production in 1914 amounted to 1,192 cwt., and in 1915 to 1,042 cwt.

MINERAL PAINTS *see* **OCHRE.**

MINERAL WATERS.

It is a curious fact, as Holland has pointed out (**859**—50, 111), that although India is endowed with large numbers of thermal and medicinal springs, no attempt has hitherto been made by the European population to turn these resources to account, with the single exception of the mineral water from the Sita-Khund hot spring in Monghyr, which has some reputation in Bengal as a table water. The natives of the country have long recognised the value of many of these springs in the alleviation of certain diseases. In some cases, as with other unusual natural phenomena, they are held sacred, and become the resort of pilgrims, often coming from great distances. At such places temples have been erected, and rest-houses with baths, into which the water of the springs is led for the use of the pilgrims.

The list given below does not pretend to include all the hot springs of India, but only those which are reputed to possess some medicinal value, or are charged with mineral matter. A comprehensive list of the thermal springs known to exist was compiled by Dr. T. Oldham and edited by Mr. R. D. Oldham in 1882 (**1327**—2). This list is arranged in accordance with the geographical distribution of the

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springs, and contains 301 entries. References to it are indicated below by the letter **O.**, followed by figures corresponding with the *number* of the entry. A few hot springs that have been described since the publication of Dr. Oldham's list are included.—Notes on brine springs, the water of which is used in the manufacture of salt, will be found under the heading **SALT.**

Lists of the hot and mineral springs of India have also been compiled by Macpherson (**1149**), R. von Schlagintweit (**1576**—8), and Buist (**228**—8).

ASSAM.

Cachar.—KOPILI (25° 30′ 30″: 92° 41′). La Touche (**1034**—3, 202). Three springs. Temp. 128-130°F. Discharge moderate. Water said to be strongly saline by Godwin-Austen, but in reality pure and tasteless. Deposits a slight calcareous incrustation (**O.** 244).

Sibsagar.—NAMBOR (26° 24′: 93° 56′). Bigge (**125**—2, 132); Medlicott (**1197**—9, 414); Prain and Masters (**1425**). Three springs. Temp. 95°, 98°, and 110°F. respectively. Discharge 8 gals. per minute. Water slightly sulphurous, but clear and palatable. Gas, slightly sulphuretted, is copiously given off (**O. 245**).

BALUCHISTAN.

Bolan Pass.—KIRTA (29° 36′: 67° 31′). King (**987**—46, 5). Copious flow of hot sulphurous water struck in a boring for petroleum, at a depth of 360 ft.

Kachhi.—LAKHA (28° 1′: 67° 30′). Masson (**1189**—1, Vol. II, 126). Hot spring. Water strongly sulphurous. Discharge copious (**O.** 45).

Las Bela.—KAN BERAR (25° 29′: 66° 3′). Vredenburg (**1854**—36, 208). Several springs, intensely saline and sulphurous. Veins of sulphur and salt are deposited in the surrounding rocks.

Sibi.—KHATTAN (29° 34′: 68° 31′). Townsend (**1794**—1, 208). Several springs of sulphurous water. Temp. 109° F. Discharge very copious. Deposit considerable quantities of sulphur and calcareous tufa.

SPINTANGI (29° 55′: 68° 8′). Oldham (**1324**—32, 107). A small sulphurous spring, about a mile to E. of the railway station.

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Uch (28° 45′ : 68° 40′). Vicary (**1845**—3, 261). Springs in centre of valley, apparently a denuded anticlinal dome, highly saline. A tepid spring is said to exist (**O.** 46).

BENGAL.

Birbhum.—Tantipara (23° 54′ 30″ : 87° 26′). Sherwill (**1625**—15, 14). A group of hot springs on the right bank of the Baklesar stream, a mile to the S. of Tantipara. Five are surrounded by masonry tanks. Temp. 128-162° F. Water impregnated with sulphuretted hydrogen. Discharge from hottest spring about 120 cub. ft. per minute (**O.** 180).

Chittagong.—Babu—or Bharat-Khund (22° 35′ : 91° 46′). Wood (**1957**); Corbyn (**363**, quoting Pogson); Rennell (*see* La Touche, **1034**—36, 177). Water cold, brackish, sulphurous, and chalybeate (not sulphurous, Rennell). Copious discharge of gas, apparently inflammable (**O.** 246).

There are eight other springs within a circuit of 6 miles :—

Balwa-Khund. Water diuretic and slightly aperient.

Naulakha-Khund. Warm and saline; vapour inflammable.

Kuari-Khund. Hot, saline, sulphurous, and chalybeate; vapour inflammable.

Dudhi-Khund. Cold, saline.

Burma—(?Brahma-) Khund. Very hot and somewhat saline; slightly chalybeate; vapour inflammable.

Chandra-Khund. Saline and exceedingly hot.

Suraj-Khund. Hot, saline, vapour inflammable.

Sita-Khund. Water pure and limpid.

Darjeeling.—Mechi (? 26° 50′ : 88° 30′). Baird-Smith (**1666**—8, 1039, quoting A. Campbell). Water clear, deposits oxide of iron; said to be efficacious for rheumatism and skin diseases (**O.** 128).

Minchu (? 27° 6′ : 88° 18′), five miles from Darjeeling. Liston (**1073**—3, 527). According to Piddington (**1405**—77), the water is carbonated, sulphurous, and chalybeate. Contains 6·74 grs. Fe_2O_3, 0·58 grs. S, and 2·04 grs. saline matter per gallon. It is said to be similar to that of Bath and one of the Harrogate springs, and to be efficacious in cases of gout, rheumatism, etc.

Jessore.—Khajura (23° 16′ 30″ : 89° 18′ 30″). Piddington (**1405**—77, 194); Watson (**1897**). Two springs, one of which is walled in. Temp. 82° F. Discharge of walled in spring, 450 gals. per hour.

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Water contains carbonate of lime and magnesia, with a small proportion of iron. Solid matter, 28·29 grs. per gallon.

BIHAR AND ORISSA.

Athmallik.—DEOLJHARI, about a mile to the N. of WODSINGA (20° 44′ : 84° 34′). Ball (**71**—43, 561). Several springs. Temp. of hottest 134° F. Slightly saline. Strong discharge of sulphuretted hydrogen.

Cuttack.—ATARI (20° 12′ : 85° 33′ 30″. Ball (**71**—43, 531). Temp. 138° F. Discharge copious, with a quantity of sulphuretted hydrogen.

Hazaribagh.—BELKAPI (24° 9′ 30″ : 85° 42′ 30″), or SURAJ-KHUND. Wilson (**1941**—2); Hooker (**867**—1, 372; —6, Vol. I, 27, Vol. II, 374); Thompson (**1771**—1, 4). Four hot and one cold spring. Temp. 169°, 170°, 190°, 173° F. respectively. Discharge copious. Deposits chloride and sulphate of soda. The water is said to act as a gentle aperient (**O.** 173).

DOARI (24° 8′ : 85° 12′ 30″). Thompson (**1771**—1, 4); Row (**1524**, 863). Temp. 110—115° F. Water sulphurous and slightly saline.

INDRA JURBA (23° 50′ : 85° 30′). Tepid; discharge small; sulphurous (**O.** 172).

KATKAMSANDI (24° 6′ 30″ : 85° 15′). Everest (**557**—1, 134); Prinsep (**1436**—8, 278). Springs rise over a space of 50 yards in length. Temp. 110° F. Water brackish and gives off sulphuretted hydrogen. Contains silica, alkaline chlorides and sulphates, and iron (**O.** 169).

KESODIH (24° 11′ 30″ : 86° 5′). Thompson (**1771**—1, 4). Temp. 182° F. Sulphurous (**O.** 174).

KOWA GANDWANI (23° 43′ : 85° 26′). Water almost tasteless, but with an odour of sulphuretted hydrogen. Temp. 92° F. (**O.** 171).

LURGUTHA (?) and PINDARKUN (? 24° 12′ : 85° 10′). Analysis given by Turner (**1813**). Water of Pindarkun spring contains 22 grs. solid matter per gallon. Siliceous and saline. Temp. 116° F. Water from Lurgutha spring is similar, containing 25 grs. solid matter per gallon. Temp. 160° F.

SOSONIA (?), N. of Hazaribagh. Piddington (**1405**—77, 195). Water contains 11·3 grs. solid matter per gallon. Carbonated and slightly chalybeate, with a little chloride of soda.

Manbhum.—SHEOPUR or SARSA-KHUND (23° 39′: 86° 36′). Sulphurous. Temp. and discharge not recorded (**O.** 175).

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TATLUI or TANTOLYA (23° 41′ : 86° 48′). Betts (**119**). Water sulphurous and slightly chalybeate. Temp. 190° F. (**O.** 176).

Monghyr.—BHIMBAND (25° 3′ 30″ : 86° 27′). Martin (**1181**, Vol. II, 198); McClelland (**1117**—33, 25); Sherwill (**1624**—2, 199); Schulten (**1587**, 148). Four groups of springs; discharge very copious. Temp. 145-150° F. Water limpid and tasteless, leaving a thin siliceous deposit. Total solids (Schulten), 6·8 parts per 100,000 (**O.** 188).

BHURKA (? 25° 18′ : 86° 37′). Martin (**1181**, Vol. II, 197). Temp. 112° F. Discharge copious.

JANAM-KHUND or BHARARI (25° 7′ : 86° 24′). Martin (**1181**, Vol. II, 199); Sherwill (**1624**—2, 198). Two springs. Temp. 145° F. Slight siliceous and calcareous deposit (**O.** 189).

LACHMI-KHUND (? 25° 3′ : 86° 29′ 30″). Schulten (**1587**, 148). Temp. 144·5° F. Not sulphurous. Leaves a slight siliceous deposit. Contains 7·52 parts solid matter per 100,000.

PANCHBHUR (25° 6′ : 86° 21′). Waddell (**1863**—1, 230). Not sulphurous. Temp. 84·4° F.

RAMESWAR-KHUND (? 25° 7′ : 86° 29′). Schulten (**1587**, 147). Not sulphurous. Temp. 112° F. Leaves a very slight deposit. Contains 4·68 parts solid matter per 100,000.

RISHI-KHUND (25° 14′ : 86° 32′). Martin (**1181**, Vol. II, 198); Sherwill (**1624**—2, 204). Water issues from a number of fissures at the edge of a pool about 140 ft. square. Discharge very copious. Temp. 104-114° F. Leaves no deposit (**O.** 187).

SINGHI RIKH TATAL PANI (25° 8′ : 86° 18′). Waddell (**1863**—1, 230). Temp. 90·5° F. Discharge copious. Not sulphurous.

SITA-KHUND (25° 22′ : 86° 36′). Adam (**7**—1, 349); Archer (**39**, Vol. II, 117); Martin (**1181**, Vol. II, 196); Waddell (**1863**—1, 230). Discharge very copious. Temp. 140° F. Water clear and tasteless, but with a slight odour of sulphuretted hydrogen (**O.** 186).

According to Hooker (**867**—6, Vol. I, 89), the water was used in 1848 for the manufacture of soda-water. It is now exploited as a table water by a Calcutta firm.

Waddell (*l.c.*) mentions two branches of the main spring at Sita-Khund, *viz.*:—GARMPANI, temp. 137° F.; and BAINSAPAHAR, about a mile to the west, temp. 102° F.; discharge very sluggish.

Palamau.—JARUM (23° 50′ : 84° 33′ 30″). Ball (**71**—32, 19; 43, 648). In the bed of the Tataka R. Several outlets. Temp. 132° F. Discharge not copious, but steady. Water emits sulphuretted hydrogen (**O.** 168).

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KOKRAHA or THATHA (23° 45′ 30″ : 84° 5′ 30″). Ball (**71**—32, 20). Discharge copious. Temp. 151° F. Water strongly impregnated with sulphuretted hydrogen (**O.** 167).

Patna.—RAJGHIR (25° 1′ : 85° 29′). Martin (**1181,** Vol. I, 256); Sherwill (**1625**—4, 59, —6, 18). There are said to be 19 hot and 4 cold springs. Temp. varies from 100° to 110° F. Combined discharge copious. Water clear and tasteless. Much resorted to for bathing (**O.** 191).

TAPOBAN (? 25° 0′ : 85° 33′). Martin (**1181,** Vol. I, 253). On southern side of the Rajgriha (Rajghir) hills. Five artificial pools from 10 to 12 ft. deep. Temp. 100° to 116° F. Discharge not copious.

Santal Parganas.—BARAMASIA (24° 30′ : 87° 42′ 30″). Waddell (**1863**—1, 227). Spring issues close to a trap dyke in limestone. Discharge about 9 gals. per minute. Temp. 93° F. Not sulphurous. Contains 36·4 parts solid matter per 100,000. Water used for drinking and bathing.

BHUMKA (24° 4′ : 87° 25′). Waddell (**1863**—1, 229). Situated in a small marsh. Temp. 82° F., reported to have been formerly much hotter. Discharge scanty. Not sulphurous.

JHARIYA- or JHERWA-PANI (24° 27′ : 87° 31′). Waddell (**1863**—1, 228). Spring situated at the eastern end of a marsh, on the faulted boundary of gneiss and coal measures. Temp. 93° F. Discharge copious. Not sulphurous (**O.** 185).

LAU-LAU-DAH or SIBPUR (24° 22′ : 87° 43′). Waddell (**1863**—1, 227); Hayden (**793**—15). Temp. 122° F. Discharge about 26 gals. per minute. Profuse discharge of gas, slightly sulphuretted. Slightly saline. Water contains 32·72 parts solid matter per 100,000.

NUNBIL (24° 5′ : 87° 13′). Waddell (**1863**—1, 228). Several springs, rising in a small marsh. Temp. 119·5° F. Discharge copious. Strong ebullition of sulphuretted gas (**O.** 183).

SUSUMPANI (24° 9′ : 87° 21′). Waddell (**1863**—1, 229). Temp. 84° F., said to have been much hotter formerly. Discharge scanty. Not sulphurous.

TAPATPANI (24° 12′ : 87° 19′). Waddell (**1863**—1, 229). Temp. 102° F. Strongly sulphurous. Discharge about 2 gals. per minute.

TAT-LOI or TAPNAI (24° 23′ : 87° 16′). Martin (**1181,** Vol. II, 200); Waddell (**1863**—1, 228). Water issues copiously over an area of about 20 by 2½ yards. Temp. 148·5° F. Slightly sulphurous (**O.** 181).

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BOMBAY.

A list of analyses of waters from various mineral springs, wells, and rivers in the Bombay Presidency was compiled in 1859 by Giraud and Haines (**662**). The letters G. & H. below refer to the springs mentioned in this list. Total solids are given in parts per 10,000 :—

Ahmadabad.—Harsol (23° 22′ : 73° 5′). G. & H. No. 19. Temp. about 80° or 90° F. Water has a peculiar taste, and is said to be very efficacious in certain diseases. Total solids, 13·84 :—NaCl =8·45 : $CaSO_4$=1·07 : Na_2CO_3=1·52 : $MgCO_3$=0·54 : $CaCO_3$=1·98 : SiO_2=0·28.

Broach.—Kawa (22° 4′ : 72° 47′). G. & H. No. 18. Cold. Total solids, 13·34 :—NaCl=6·74 : Na_2SO_4=2·04 : Na_2CO_3=1·94 : $MgCO_3$ =1·58 : $CaCO_3$=0·57 : SiO_2=0·47. The water is considered to be a specific preventive of hydrophobia.

Cutch.—Mhurr (23° 33′ : 69° 0′ 30″). Wynne (**1975**—11, 265). A strong spring of warm saline water supplies a reservoir about 330 sq. yards in extent. The water is used at the alum works in the neighbourhood (**O.** 26).

Kaira.—Lasundara (22° 55′ : 73° 12′). Yajnik (**1979**); G. & H. No. 20. Three groups of springs :—(1) seven springs. Temp. 100° to 122° F. (2) one spring. Temp. 101° F. (3) nine springs. Temp. 87° to 114° F. The hottest springs are strongly sulphurous, and the water is saline. It is used in diseases of the skin. Total solids, 60·76 :—NaCl=42·35 : $CaCl_2$=14·53 : $CaSO_4$=3·88 (**O.** 145).

Kathiawar.—Tulsi Sham (21° 3′ : 71° 5′), in the Gir hills. Jacob (**924**—2, 36); G. & H. No. 23. Temp. 124° F. Water used for bathing, but has no medicinal properties. Total solids, 11·87 :—NaCl= 7·92 : Na_2SO_4=1·13 : $CaSO_4$=0·41 : $CaCO_3$=1·33 : SiO_2=1·08 (**O.** 24).

Kolaba.—Pali (18° 32′ 30″ : 73° 17′). G. & H. No. 4. The spring is a mile from the village. Emits gas of unpleasant odour. Temp. 108° F. Total solids, 26·05 :—NaCl=11·01 : $CaCl_2$=13·28 : $CaSO_4$ =1·43 : SiO_2=0·33. Supposed to be efficacious in skin diseases (**O.** 10).

Sapa or Savi (18° 5′ : 73° 24′). G. & H. No. 7. Three springs. Water sulphurous when fresh. Total solids, 11·4, consisting of chlorides of soda and lime, with sulphate of lime (**O.** 9).

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Panch Mahals.—TUWA or TUI (22° 48′ : 73° 34′). G. & H. No. 21. Numerous hot springs, some near boiling point, rising in a marsh. Water emits a rank sulphurous vapour. Total solids, 47·70 :—NaCl=36·69 : $CaCl_2$=7·19 : $CaSO_4$=3·82 (**O.** 146).

Ratnagiri.—ARAULI (17° 19′ : 73° 35′). Hazlewood (**796**); G. & H. No. 1. Three hot and two cold springs. Temp. 105° F. Water strongly impregnated with sulphur. Discharge about 1 gallon per minute. Total solids, 4·9, consisting of chlorides of soda and lime, with sulphate of lime (**O.** 5).

MAT (16° 57′ : 73° 33′ 30″). Duncan (**511**). The water is said to induce appetite. Temp. 157° F. (**O.** 2).

RAJAPUR (16° 39′ : 73° 35′). Duncan (**511**); Mann and Paranjpé (**1165**); G. & H. No. 5. Springs intermittent, said to flow every two or three years. Discharge about 6 gals. per minute. Temp. about 90° F. Water alkaline, containing traces of common salt and sulphate of lime. Much resorted to for bathing (**O.** 1).

SANGAMESHWAR (17° 11′ : 73° 37′). Duncan (**511**); Hazlewood (**796**); G. & H. No. 9. Springs about 3 miles from the town, rising in the bed of a rivulet. Temp. 105° F. Water slightly sulphurous. Total solids, 1·3 (**O.** 3).

TURAL or RAJWADI (17° 15′ : 73° 37′). Duncan (**511**); Hazlewood (**796**); G. & H. No. 10. Spring rises from trap; discharge about 1½ gal. per minute. Temp. about 110° F. Water slightly sulphurous. Total solids, 9·6, consisting of traces of common salt and sulphate of lime (**O.** 4).

UNARI (17° 37′ : 73° 23′). Duncan (**511**); G. & H. No. 3. Several springs. Temp. ? 157° F. Water emits a strong sulphurous odour. Total solids, 19·06 :—NaCl=12·83 : $CaCl_2$=4·17 : $CaSO_4$=1·59 : SiO_2=0·47 (**O.** 6).

Sind.—JAIN PIR (25° 0′ 30″ : 68° 4′). G. & H. No. 25. Hot spring. Temp. not recorded. Total solids, 18·34 :—NaCl=11·56 : Na_2SO_4=2·02 : Na_2CO_3=2·11 : $CaCO_3$=2·17 : SiO_2=0·48 (**O.** 28).

LAKI (26° 15′ 30″ : 67° 57′). Vicary (**1845**—5, 342); Baker (**63**, 231). Three hot springs. Temp. 102° to 105° F. The water of one spring is highly saline. That of another is sulphurous and slightly saline, with calcareous matter. It has a great reputation as a remedy in skin diseases (**O.** 36).

MANGA or MUGGER PIR (24° 59′ : 67° 6′). Carless (**284**—3); Baker (**63**); G. & H. Nos. 26-28. Three springs. Temp. 99°, 119°, and 127° F. respectively. Discharge copious. Water tasteless, slightly chalybeate when fresh, and sulphurous on issuing. It is

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held in great estimation for the cure of rheumatism, leprosy, and skin diseases. Total solids, hottest spring, 10·50 :—$CaCl$=6·64 : $MgCl_2$=0·65 : Na_2SO_4=1·37 : $CaSO_4$=1·76 : SiO_2=0·08 (**O.** 27).

PITH or GHAZIPIR (26° 27′ : 67° 30′). Vicary (**1845**—5, 345) ; Baker (**63,** 231) ; Water very hot, highly calcareous, and charged with sulphuretted hydrogen. Discharge copious (**O.** 42).

SEHWAN (26° 25′ 30″ : 67° 55′). Springs of hot sulphurous water occur about 3 miles to the S. of the town (**O.** 39).

WAGODUR (24° 48′ : 67° 16′). G. & H. No. 30. Temp. not recorded. Total solids, 22·77 :—$NaCl$=10·44 : $MgCl_2$=5·04 : Na_2SO_4 =5·58 : $MgCO_3$=0·36 : $CaCO_3$=0·93 : SiO_2=0·18.

Surat.—ANAVAL or DEVAKI UNEI (20° 51′ : 73° 24′). Sykes (**1736**—1, 427) ; G. & H. No. 17. Several springs. Discharge more than 2 cub. ft. per minute. Temp. 115° to 120° F. Water emits sulphurous gas. Total solids, 12·79 :—$NaCl$=8·46 : $CaSO_4$=1·64 : Na_2CO_3=1·86 : $CaCO_3$=0·15 : SiO_2=0·68. White has given an account of the annual fair held here at the full moon of the month *Chaitra* in the *Transactions, Royal Asiatic Society*, Vol. III, p. 372 (**O.** 23).

Thana.—KOKNER (19° 42′ 30″ : 72° 54′). G. & H. No. 2. Several hot springs. Temp. not recorded ; as hot as can be borne by the hand. Total solids, 80·45 :—$NaCl$=27·78 : $MgCl_2$=0·39 : $CaCl_2$=50·03 : $CaSO_4$=1·89 : SiO_2=0·36 (**O.** 19).

SATIWALI (? 19° 45′ : 72° 51′). G. & H. No. 8. Four hot springs. Water saline (**O.** 20).

VIZRABHAI (19° 29′ 30″ : 73° 6′). Sykes (**1736**—1, 427) ; G. & H. No. 11. Several springs, rising in the bed of the Tansa R. Temp. 110° to 136° F. Discharge of the most copious spring about 12 gals. per minute. Water emits sulphuretted hydrogen and is said to induce appetite. Total solids, 22·64 :—$NaCl$=12·41 : $CaCl_2$= 7·07 : $CaSO_4$=2·08 : SiO_2=0·88 (**O.** 11).

BURMA.

Amherst.—ATARAN (16° 9′ : 98° 2′). Low (**1097**—2, 154 ; —4, 235) ; Foley (**595**—4, 276) ; Helfer (**808**—5, 22). Several springs, the largest forming a pool about 60 ft. in diameter. Highest temp. recorded 146° F. (Helfer). Discharge very copious. Water strongly impregnated with iron, and has an exceedingly bitter taste. A large quantity of carbonic acid gas is evolved. According to Piddington (**1405**—3), the water contains lime, iron, and magnesia (**O.** 274).

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NATMOO, on Bilugyun I., near MAULMEIN (16° 30′ : 97° 40′). Romanis (**1511**—1 ; —2). The spring forms a circular pool 12 ft. in diameter and 4 ft. deep. Temp. 130° F. The water contains 14·07 grammes of solid matter per litre, including 10·446 grm. of sodium chloride and small quantities of the chlorides of potassium, lime, and magnesia.

SIENLI (?). Prinsep (**1436**—5, 17). Water contains sulphate of lime and traces of iron (**O.** 263).

Karenni.—KYAI KYAUNG (?). O'Riley (**1340**—10, 447). Springs extend for about half a mile on both banks of the stream. Temp. of the principal sources, 99°, 125°, and 128° F. Water decidedly alkaline.

YE-BU (?), in the valley of the Myet-nan-Kyaung, E. of Toungoo. O'Riley (**1340**—9, 51). Water clear and limpid, leaves no deposit. Temp. 138° F.

Mergui.—PALAUK (13° 16′ : 98° 44′). Macleod (**1139**—2). Springs occur at three places in groups, the largest consisting of 30 or 40 springs along a line of about 50 by 20 ft. Temp. 196° F. The water has no disagreeable taste (**O.** 287).

Myitkyina.—SUPYA KYAUNG, near the JADE MINES (25° 42′ : 96° 17′). Griffith (**709**—4, 88). Water clear, alkaline.

Shan States (N.).—LASHIO (22° 56′ : 97° 47′). Noetling (**1311**—4, 111). Hot spring about 5 miles to N. of the town. Discharge very copious. Temp. near boiling point. Water contains about 0·05 per cent. total salts, consisting of sulphate of lime and magnesia, with traces of alkalies. The water "would act as an aperient and be highly beneficial in cases of chronic rheumatism and gout."

NAMÔN (22° 29′ : 97° 14′). La Touche (**1034**—45, 363). Group of hot springs. Temp. 150° to 180° F. Discharge copious. Water clear and tasteless, very slightly saline. Deposits calcareous tufa.

Shan States (S.).—KEHSI MANSAM or BAN-SAN (21° 56′ : 97° 52′). Fedden (**569**—1, 44). Group of hot springs. Temp of hottest, 104° F. Water clear, highly calcareous.

Sutherland (**1729**—1, 197) mentions the occurrence of sulphurous hot springs in several of the streams between WAIHANG (21° 11′ : 98° 47′) and MONG PING (21° 22′ : 99° 1′), on the road from Taunggyi to Keng Tung.

MEGHRAJ ARCHIVES OF INDIA

Tavoy.—ENG-BEIN-BYIN or YEBU-SAN (? 14° 43′ 30″ : 98° 12′). Low (**1097**—4, 218) Spring forms a pool about 40 ft. in diameter in the middle of a swamp. Temp. 104° F.

LAUKYEN (LAUKCHAN, 14° 9′ : 98° 20′). Low (**1097**—2, 148); Prinsep (**1436**—5). Water contains 2 grs. of sulphate of lime in 1,000. Temp. 144°F. (**O.** 283).

MYITTHA (14° 10′ : 98° 32′). Mason (**1185**—1, 17). On the Great Tenasserim R., 4 miles below the village. Temp. 119° F. Water strongly charged with sulphuretted hydrogen. Chalybeate (**O.** 280).

PAI (13° 26′ : 98° 33′). Mason (**1185**—1, 18); Stevenson (**1699**). Several springs. Temp. of hottest, 198° F. (Mason). Water has no unpleasant taste or smell. Contains iron, alumina, lime, potash, soda, silica, hydrochloric and sulphuric acids (**O.** 286).

CENTRAL PROVINCES.

Chhindwara.—ANHONI (22° 36′ : 78° 38′ 30″). Spilsbury (**1684**—1; —4, 389); Prinsep (**1436**—5, 17). Water issues from a trap dyke. Temp. 134° F. Discharge copious. Strongly sulphurous (**O.** 156).

Hoshangabad.—ANHONI SAMONI (22° 38′ : 78° 25′). Spilsbury (**1684**—1;—4, 389). Water issues at the edge of a trap dyke for a distance of a quarter of a mile. Temp. 114° F. Abundant discharge of sulphuretted hydrogen (**O.** 155).

Surguja.—TATAPANI (23° 41′ : 83° 43′). Ball (**71**—32, 21;—43, 663). Not less than a score of springs on or near a ridge of pseudomorphic quartz and breccia marking a line of fracture. Temp. varies from 130° to 190° F. Discharge copious. Water deposits siliceous sinter, and emits a strong odour of sulphuretted hydrogen (**O.** 166).

Yeotmal.—KHAIR (19° 54′ : 78° 58′). Malcolmson (**1158**—7, 115). Several springs; discharge very copious. Temp. 87° F. Water clear but has an acid taste. Deposits large quantities of calcareous tufa (**O.** 204).

HYDERABAD.

Gulbarga.—WUJUL (16° 28′ 30″ : 76° 36′ 30″) and MUDNOOR (MUDANUR, 16° 36′ : 76° 33′) near Shorapur. Meadows Taylor (**1751**—2, 30, 31) mentions warm springs at these localities. Both have a very copious discharge. Temp., Wujul, 92° F.; Mudanur, 88° F. Water pure and insipid in taste.

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Warangal.—Baiora or Buga (17° 56′ : 80° 47′). Voysey (**1853**—6, 397); Malcolmson (**1158**—8, 565). Spring forms a pool 40 ft. by 30 ft. in extent and 5 ft. deep. Temp. 110° F. Water tasteless and pure; contains a little carbonate of lime in solution. Discharge small (**O.** 206).

KASHMIR.

Baltistan.—Askoli or Chongo (35° 41′ : 75° 48′). Godwin-Austen (**669**—4, 42); Lydekker (**1109**—26, 54); Guillarmcd (**722**—2, 132). Several springs. Discharge very copious. Temp. 104·5° F. Emits large quantities of sulphuretted hydrogen, and deposits much carbonate of lime (**O.** 107).

Bisil or Behitsil (35° 52′ 30″ : 75° 27′). Vigne (**1846**—4, Vol. II, 285); Lydekker (**1109**—26, 54). Water highly charged with sulphuretted hydrogen. Temp. about 160° F. Deposits large quantities of calcareous tufa and sulphur (**O.** 103).

Chutran (35° 42′ : 75° 28′ 30″). Godwin-Austen (**669**—4, 46); Lydekker (**1109**—26, 54). Discharge very copious. Temp. 110° F. Water without taste or smell. Deposits large quantities of calcareous tufa (**O.** 104).

Duchin (Dushkin, 35° 28′ : 74° 51′). Vigne (**1846**—4, Vol. II, 301). Two springs, sulphurous and slightly chalybeate. Temp. 154° F. Deposits sulphur (**O.** 102).

Khorkan (35° 20′ : 76° 50′). Vigne (**1846**—4, Vol. II, 388). Water sulphurous. Temp. 185° F. Deposits gypsum and sulphur (**O.** 109).

Tosha (35° 44′ : 75° 44′). Lydekker (**1109**—26, 54). Three springs. Water highly charged with ferrous carbonate (**O.** 105).

Changchengmo.—Gokra (34° 25′ : 78° 58′ 30″). Henderson and Hume (**815**, 72); Cayley (**294**—1, 45). Several springs. Water highly charged with carbonic acid gas. Temp. 120° to 150° F. Deposits of borax and common salt occur near the springs (**O.** 113).

Kashmir.—Islamabad (33° 44′ : 75° 13′). Adams (**8**—2, 200). Two springs. Tepid. Water sulphurous (**O.** 77).

Pampur (34° 1′ : 74° 59′). Vigne (**1846**—4, Vol. II, 34); Hugel (**881**—3, Vol. I, 260). Water issues from contorted limestone rocks. Temp. 70° F. Emits sulphuretted hydrogen. Said to resemble the water of the Spas near Weymouth (**O.** 76).

Ladakh.—Knarung, about a mile to N. E. of Skio (34° 0′ : 77° 19′ 30″). Moorcroft (**1246**, Vol. I, 416). Water tepid, without

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any decided flavour. Deposits an incrustation of soda, and is said to be used as an emetic (**O.** 111).

Nubar.—CHUSAN or PANAMIK (34° 47′ : 77° 36′). Moorcroft (**1246**, Vol. I, 405); Thomson (**1777**—3, 407). Two springs. Temp. 167° F. Faintly sulphurous, not perceptibly saline. Deposits calcareous tufa and soda (**O.** 110).

Rupshu.—PUGA (33° 14′ : 78° 25′). Cunningham (**399**—5, 144); Thomson (**1777**—3, 164). Springs numerous, extending for about 2 miles along the course of the river. Temp. varies from 80° to 174° F. The hottest springs contain sodium chloride and emit sulphuretted hydrogen. Those of lower temperature deposit borax. Sulphur and gypsum are deposited near the springs (**O.** 117).

MADRAS.

Bellary.—RAMANDRUG (15° 7′ 30″ : 76° 32′). Mayne (**1195**). Water slightly carbonated and chalybeate, with traces of alumina and lime.

Godavari.—GONDALA (17° 39′ : 81° 0′). Voysey (**1853**—6, 396). Spring rises in bed of Godavari R. Temp. 140° F. Emits slight odour of sulphuretted hydrogen. Contains small quantities of sulphate of soda, common salt, and chloride of lime (**O.** 205).

Kurnool.—KALVA (15° 37′ : 78° 16′). Newbold (**1294**—52), Three springs, situated a mile and a half to S. of the village. Temp. 90° F. Discharge copious. Water colourless and tasteless. Deposits thick beds of calcareous tufa (**O.** 211).

LANJABANDA (15° 30′ : 78° 3′ 30″). Newbold (**1294**—30). Several springs, situated about a mile to E. of the village. Temp. 85·3° F., said to be decreasing. Water slightly alkaline; deposits calcareous tufa and siliceous sinter (**O.** 213).

MAHANANDI (15° 29′ : 78° 41′). Newbold (**1294**—52); Gopalakristnamah Chetty (**675**, 11). Several springs. Temp. 89° F. Discharge copious. Water clear and tasteless, but slightly acid (**O.** 214).

MYSORE.

Bangalore.—BANGALORE (12° 58′ : 77° 38′). A. Z. (**1**). Water from a well in the Cantonment contains 7·10 grs. carbonate of iron and 2 grs. sodium chloride, with a trace of carbonate of lime dissolved in carbonic acid. It is considered to possess the same properties as Cheltenham water.

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PUNJAB.

Gurgaon.—SOHNA (28° 15′ : 77° 8′). Ludlow (**1099**); Jacquemont (**926**—3, Vol. III, 337). Water strongly charged with sulphuretted hydrogen. Not chalybeate. Temp. 108° F. It is said to resemble Moffat water, and is largely resorted to for the cure of skin diseases (**O.** 136).

Kangra.—JAWALA MUKHI (31° 52′ : 76° 23′). Parish (**1363**—1, 285); Moorcroft (**1246**, Vol. I, 73). Water saline, used as a cure for goitre. Marcadieu (**1168**—4) has determined the amount of salt and iodine in the water of six springs situated in the Jawala Mukhi valley. These are, in 1,000 parts :—

	Salt.	Iodine.
KUPERA spring	22·0	0·0799
JAWALA ,,	26·30	0·09324
JAWALA, 2nd spring	24·0	0·0799
JAWALA MUKHI	22·80	0·0799
NAGIA spring	22·20	0·09324
KANGRA BASA	23·0	0·09324

LAUSA (32° 23′ : 76° 5′). Marcadieu (**1168**—7). Water sulphurous. Temp. 72° F. Water resembles that of Baréges, Haute Pyrénées, and contains, in 1,000 parts :—Na_2SO_4=0·159 : NaCl= 0·740 : Na_2CO_3=2·600 : $CaCO_3$=0·040. It is used as a cure for goitre (**O.** 67).

TATWANI (32° 7′ : 76° 46′). Spring rises in the bed of the Lum, a tributary of the Birmi R. Temp. 120° F. Water exceedingly nauseous, with a metallic flavour (**O.** 69).

TIVA or JIVA (32° 8′ : 76° 14′). Marcadieu (**1168**—5 ; —6). Saline spring. Temp. 108° F. Estimated discharge, 250 pints in 5 minutes. Water limpid, with a saline taste and slightly alkaline. Residue contains 92·33 per cent. of sodium chloride, with small quantities of chloride, sulphate, and carbonate of lime; also 0·012 parts of sodium bromide in 1,000. The water is compared with that of Bourbonne les Bains, Haute Marne (**O.** 68).

(Kulu).—BASHISHT (32° 16′ : 77° 15′). Harcourt (**763**—2, 339); Calvert (**265**—2, 49). Three springs, one of which gives a copious discharge. Temp. 138° F. (120° F., Calvert). Sulphuretted hydrogen emitted. Much resorted to for medicinal purposes (**O.** 79).

KHELAT- or SITA-KHUND, near MONALI (32° 15′ : 77° 14′). Cunningham (**399**—3, 208); Harcourt (**763**—2, 339); Calvert (**265**—2, 38). Water sulphurous, and possesses a bitter taste. Temp. 104° F. (**O.** 80).

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MANIKARN (32° 2′ : 77° 25′). Parish (**1363**—1, 290 ; —2, 392) ; Marcadieu (**1168**—3, 197) ; Harcourt (**763**—2, 339) ; Calvert (**265**—2, 77) ; Bruce (**219**—2, 181). Fourteen springs. Temp. varying from 160·5° to 202° F., or the boiling point proper to the elevation, 5,587 feet. Discharge exceedingly copious. Sulphuretted hydrogen is emitted, but the water is clear and palatable, containing 3·2 parts of saline matter in 10,000. It deposits large quantities of ferruginous travertine (**O.** 83).

(Spiti).—CHANGRIZANG (32° 3′ : 78° 40′). Water issues from 7 or 8 small vents within a space of about 20 yards. Strongly charged with sulphuretted hydrogen. Temp. 117·5° F. Deposits a saline incrustation. Gerard (**647**—2, 142) says that each spring is reckoned a specific against some complaint ; and that directions for drinking and bathing are engraved in the Tartar language on slabs of stone placed beside the appropriate vent. The water is said to excite a great appetite (**O.** 121).

Mianwali.—BAKH RAVINE (32° 40′ : 71° 51′). Fleming (**591**—5, 265). Water strongly charged with sulphuretted hydrogen. Temp. 94° F. Deposits sulphur on evaporation.

Patiala.—PINJAUR (30° 48′ : 76° 59′). Henwood (**824**—1). Two springs. Chalybeate and sulphurous. Temperature not recorded, but said to be decreasing.

Simla Hill States (Bashahr).—JAORI (31° 32′ : 77° 50′). Colebrooke (**337**—4, 127) ; Lloyd and Gerard (**1079,** Vol. I, 198). Five springs. Temp. 130·5° F. Water clear, with a strong sulphurous smell (no smell, L. & G.) and disagreeable saline taste. Deposits ferruginous matter (**O.** 86).

(Bhajji).—SUNI (31° 14′ 30″ : 77° 11′). Gerard (**647**—2, 142) ; Prinsep (**1436**—5, 17). Eight or ten springs on right bank of Sutlej R., opposite the village. Temp. 135° F. Water strongly sulphurous, with a very disagreeable saline taste. Contains chloride and sulphate of soda (**O.** 71).

(Bilaspur).—BHASRA (31° 14′ : 76° 47′). Wade (**1862**—3). Near the source of the Lohand Khud. Temp. not recorded. Water strongly saline, and has a slightly aperient quality. Said to be efficacious in cases of scrofula, dropsy, and rheumatism (**O.** 70).

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RAJPUTANA.

Mewar (Udaipur.)—GANGAR (25° 3′ : 74° 40′). Hardie (**764**—7, 53). Spring rises through sandstone. Temp. 80° F. Water slightly saline and sulphurous (**O.** 144).

SIKKIM.

BEOPERTAM (27° 34′ : 88° 23′). Shawcross (**1616**, 592). On right bank of the Rinpiram R., a short distance below its junction with the Ronghep. Two springs. Temp. not recorded. Water strongly impregnated with sulphuretted hydrogen.

MOMAI (27° 55′ : 88° 45′). Hooker (**867**—3, 51; —6, Vol. II, 133, 375). Springs about a mile below the foot of the Kinchinjhau glacier. Temp. 110° to 116° F. Water strongly sulphurous. Contains 25 grs. per gallon of sodium chloride, sulphate and carbonate. Strongly alkaline when concentrated (**O.** 132).

PHUG SACHU (27° 14′ : 88° 21′). Baird Smith (**1666**—8, 1039, quoting A. Campbell). Water has a disagreeable smell and deposits a whitish substance. It is used medicinally. A similar spring issues at PUKLAZ SACHU, also on the Great Rangit R. (**O.** 129, 130).

YEUMTONG (27° 49′ : 88° 45′). Hooker (**867**—6, Vol. II, 116, 374). Several springs. Temp. 112·6° F. Discharge a few gallons per minute. Water has a slightly saline taste, and emits sulphuretted hydrogen. Contains chloride and sulphate of soda. Used for bathing (**O.** 131).

TIBET.

Hundes.—TIRTAPANI (31° 8′ : 80° 52′). Moorcroft (**1245**—1, 459). Two springs. Water clear and very hot. Deposits calcareous tufa (**O.** 123).

Tsang and U.—KAMPA DZONG (28° 17′ : 88° 34′). Hayden (**793**—12, 137). Springs situated about 5 miles to N. N. E. of village. Temp. 140° to 175° F. Water strongly sulphurous. Extensive deposits of calcareous and siliceous tufa surround the springs.

KHANGMA (28° 33′ : 89° 44′). Hayden (**793**—12, 137). Springs formerly more active. Large masses of travertine have been deposited. Temp. not recorded.

YOJA (27° 48′ : 89° 2′). Hayden (**793**—12, 136). Thirteen springs. Temp. probably about 110° F. Water distinctly sulphurous. Greatly frequented for medicinal purposes, chiefly the cure of skin diseases and rheumatism. Each bath is supposed to be specially adapted for the treatment of a specific disease.

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UNITED PROVINCES.

Banda.—BANDA (25° 29′ : 80° 23′). Prinsep (**1436**—5, 17). Water from well used in lac dyeing. Temp. normal. Strongly charged with sulphuretted hydrogen. Contains small quantities of chloride of soda and magnesia, with carbonates of lime and potash.

Benares.—BENARES (25° 18′ : 83° 4′). Prinsep (**1436**—1). Water from the Bridhkal Khund, a well in the city. Contains 7·4 grs. of solid matter in 1,000, consisting of chlorides and nitrates of soda and potash, with a little sulphate of soda and carbonate of lime. It is said to possess slightly aperient qualities when taken in large doses.

Dehra Dun.—LANDOUR (30° 27′ : 78° 10′). Murray (**1274**). Several chalybeate and sulphurous springs occur in the neighbourhood. Details of a number of cases in which the use of the waters has proved beneficial are given. These include debility, diseases of the liver and spleen, rheumatic and cutaneous complaints, etc.

SAHASRADHARA (30° 23′ : 78° 11′). Ainsworth (**18**, 43). Water strongly impregnated with sulphuretted hydrogen. Temp. 72° F. Deposits a thick coating of sulphur on the sides and bottom of the spring (**O.** 72).

Garhwal.—GAURIKHUND (30° 39′ : 79° 5′). Anon. (**35**—42); Hoffmeister (**855**, 211). Two springs, hot and cold. Temp. of hot spring about 130° F. Discharge copious. Water has no taste or smell, but contains carbonates of lime and iron. Water of cold spring slightly saline and strongly chalybeate. Temp. 72° F. (**O.** 95).

PALIA or WAZIRGARH (30° 54′ : 78° 23′), Fraser (**619**—3, 185). Several springs. Water tepid, clear, impregnated with sulphuretted hydrogen and iron (**O.** 90).

TAPOBAN (30° 29′ : 79° 41′). Moorcroft (**1245**—1, 380). Discharge fairly copious. Temp. not recorded, but very hot. Water chalybeate; deposits a yellow incrustation.

Tehri Garhwal.—Jamnotri (31° 0′ : 78° 31′). Fraser (**619**—3, 196;—4, 428; —5, 227); Hodgson (**851**—1, 147); Jacquemont (**926**—3, Vol. II, 89). Numerous springs. Temp. 192·6° F. Discharge very copious. Water transparent and tasteless (bitter and ferruginous, according to Jacquemont). Deposits a thin calcareous and ferruginous sediment (**O.** 92).

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MOLYBDENUM.

BIHAR AND ORISSA.

Small quantities of molybdenite have been found in some of the metamorphic rocks of Chota Nagpur, and in the lead mines of Hazaribagh (**B.** 161).

A sample of molybdenite from an unknown locality, obtained from a firm in Calcutta, was found by Prinsep (**1436**—23, 514) to contain 74·4 per cent. of molybdic acid.

BURMA.

Tavoy.—Molybdenite is mentioned by Bleeck (**154**—4, 68) among the minerals occurring in the wolframite lodes of Tavoy, but so far it has been found in negligible quantities only.

MADRAS.

Godavari.—A discovery of molybdenite recently made in sinking a well at KUNNAVARAM (17° 34′ : 81° 16′) has been investigated by Cotter (*see* Hayden, *Records, G. S. I.*, Vol. XLVII, 22). The mineral was obtained in considerable quantity from a vein of pegmatite, but it appears to be merely a sporadic occurrence, and there is no reason to suppose that a large amount will be found in the neighbourhood.

Travancore.—Scales of a plumbago-like mineral, which has proved to be molybdenite, occur abundantly disseminated through a vein of pyrrhotite opened up by Masillamani (**298,** 13) at MANGAMALAI HILL, about 2 miles to the W. of ARUMANALLUR (8° 19′ : 77° 28′), in the Tovala Taluk.

Chacko (**298,** 53) states that 1 per cent. of molybdenum oxide was found in the ash of the Warkalli lignite; but in two samples of the ash, analysed at the Imperial Institute (*Ibid.*, pp. 81, 82), only the merest traces of molybdenum, not amounting to more than 0·007 per cent., could be detected.

RAJPUTANA.

Kishangarh.—Molybdenite has been detected in an elæolite-sodalite-cancrinite pegmatite described by Vredenburg (**1854**—10), occurring at Mandaoria (26° 36′ 30″ : 74° 57′ 30″) near Kishangarh (**862,** 284).

MINERAL ARCHIVES OF INDIA

MONAZITE.

Monazite, which constitutes the raw material for the preparation of thorium nitrate, used in the manufacture of gas mantles, appears to be widely distributed in India, but as yet deposits of commercial value have been found only in the Madras Presidency. It has been detected by Middlemiss in sand concentrates from the SABARMATI R. in Idar State, Bombay; by Annandale on the coast at the entrance to the CHILKA LAKE in Orissa (*see* Tipper, **1787**—12, 195); and in a sample of sand concentrates collected by Hayden (**793**—12, 190) on the Tsangpo R. near CHAKSAM (29° 20′ : 90° 44′) in Central Tibet.

MADRAS.

Tinnevelly.—Monazite occurs in the older dunes, in the dry beds of streams draining eastwards from the hills, and in the beach sands where they have undergone slight concentration (*see* Tipper, **1787**—12, 195).

Travancore.—In the year 1909 it was discovered by Schomburg that the sands of the coast in the neighbourhood of Cape Comorin contain in places large quantities of monazite. These deposits have since been examined in detail by Tipper (**1787**—12) and Chacko (**298**, 83). Concentrations of monazite sand have been found at the following localities :—

CAPE COMORIN—LIPARUM (8° 6′ : 77° 37′).
MUTTUM—PUDUR (8° 9′ 30″ : 77° 20′ 30″).
KOVILAM (8° 23′ 30″ : 77° 2′).
ANJENGO—WARKALLI (8° 44′ : 76° 46′).
NINDIKARAI (8° 58′ : 76° 36′ 30″).

No workable deposits have been found to the north of the Kallada R., which enters the sea near Quilon, though monazite is present in the sands of some of the rivers of north Travancore and Cochin. Concentration usually takes place where the scour caused by the long-shore currents renders the slope of the beach comparatively steep. In such places the sorting action of the waves, during the N. E. monsoon period, is most effective. The colour of the sands is black where magnetite and ilmenite predominate, but red or yellow where garnets or monazite respectively are in excess. The monazite occurs in the form of rounded grains, varying from 0·1 to 0·2 mm. in diameter, of an amber colour.

Monazite is also found in the sand dunes fringing the coast between Cape Comorin and Anjengo; and in a ferruginous grit of late

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Tertiary age, exposed at the base of the Warkalli cliffs. This probably represents an old beach concentrate.

Monazite *in situ* was first discovered by Mr. Herbert in the graphite mines at Vellanad (8° 34′ : 77° 7′), where it occurs with graphite in a rock, probably a pegmatite, filling a fault crack. It has also been found by Masillamani (**298,** 7 ; **1183,** 6) in pegmatites intrusive in garnetiferous granulites and charnockites near Islandimangalum (8° 15′ : 77° 29′ 30″), and at other localities in the Tovala Taluk. The monazite is present as an original constituent of the rock, and sometimes occurs in considerable abundance ; but Tipper (**1787**—12, 194) is of opinion that the bulk of the monazite in the shore sands is derived from the gneiss of Travancore.

The proportion of thoria present in Travancore monazite shows considerable variation. A sample analysed by Christie at the Geological Survey laboratory yielded 6·0 per cent. ThO_2 (*see* Tipper, **1787**—12, 194). A sample of the naturally concentrated sand from near Quilon, examined by Crook and Johnstone (**391**—2) at the Imperial Institute, contained over 46 per cent. of monazite, in which the thoria content amounted to 8·5 per cent. While two samples analysed by Johnstone (**950,** 57) yielded 8·65 and 10·22 per cent. of thoria respectively.

During the years 1911 to 1913, the total output of monazite in Travancore amounted to 3,202 tons, valued at £107,475. In 1914 the production was 1,185½ tons, valued at £41,411, and in 1915, 1,108 tons, valued at £33,283.

Vizagapatam.—Streaks of black sand with monazite have been observed on the coast at Waltair (17° 44′ : 83° 24′) by Kemp, and at Bimlipatam (17° 53′ : 83° 31′) by Cross (*see* Tipper, **1787**—12, 195).

NICKEL.

AFGHANISTAN.

Traces of nickel were detected by Mallet in a contact rock described by Griesbach (**708**—4, 55) as occurring near Kandahar (31° 37′ : 65° 45′) along the junction of intrusive basalt with hippuritic (Cretaceous) limestone (**B.** 326).

BURMA.

Henzada.—Nickel has been found in specimens of pyrite said to have been obtained in the Henzada district (**862,** 281).

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MADRAS.

Travancore.—The sulphide ores occurring near ARUMANALLUR (8° 19′ : 77° 28′) in the Tovala Taluk, described by Masillamani (**298,** 13, 30), contain small quantities of nickel. A surface sample showed 0·64 per cent. of nickel (**862,** 281).

RAJPUTANA.

Alwar.—BHANGARH (27° 5′ 30″ : 76° 21′). Specimens of iron and iron ore obtained by Hacket (**730**—2, 92) at this locality contained traces of nickel (**B.** 326).

Jaipur.—KHETRI (28° 0′ : 75° 51′). A trace of nickel was detected by Mallet (**1159**—24, 195) in samples of cobaltite from the Khetri copper mines (**B.** 326).

NIOBIUM *see* **RARE MINERALS—COLUMBITE** *and* **SAMARSKITE.**

OCHRE.

Ochreous lithomarges or bole of various colours suitable for use as pigments are abundantly distributed in the Indian peninsula and Burma in association with laterite, and are largely employed, under the generic name *geru*, for colouring the walls of houses, making caste marks, etc. Deposits of a similar character also occur among rocks of various geological ages, down to the Archæan hematites. **Barytes** (*q. v.*) is sometimes used as a substitute for 'white lead.' The following occurrences of ochre have been specially noted:—

BIHAR AND ORISSA.

Gaya.—An indurated reddle, of orange, purple, light red, or yellow colours, quarried from a small hill situated to the W. of GAYA (24° 47′ : 85° 4′), is used, according to Sherwill (**1625**—4, 59; —6, 18), for dyeing cloths.

Mayurbhanj.—Bose (**173**—20, 170) mentions that red and yellow ochres are met with at places, and are used as colour washes.

Santal Parganas.—Buchanan-Hamilton (**222**—19, 4) mentions the frequent occurrence of beds of ochre in connection with the kaolin deposits of the Rajmahal hills. Fragments derived from these beds are collected from the streams, especially near KHARI PAHAR, at the southern end of the hill range, and are used for colouring.

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Shahabad.—Sherwill (**1625**—5, 283) states that extensive beds of ochre are exposed on the Kaimur plateau at MANDPA (24° 44′ : 83° 40′ 30″) and CHUTHAN (24° 38′ : 83° 44′), and that the material is carried to Patna, Benares, etc., for dyeing and use as a pigment.

Singhbhum.—According to Haughton (**785**—1, 118), red ochre is said to be found abundantly on the KOLHAN estate in pargana Saranda; and yellow ochre at several places in KHARSAWAN (22° 48′ : 85° 53′).

BOMBAY.

Bijapur.—A bed of fine white and red clay, occurring in sandstones at the summit of a spur from the SITADONGA HILLS overlooking the Ghatprabha R., to the E. of BHAGALKOT (16° 11′ : 75° 46′), is mentioned by Newbold (**1294**—41, 272) as being extensively used as whitewash, and for painting caste marks.

Foote (**596**—12, 266) remarks that beds of red bole are found in many places on the Deccan trap, and that the material has been experimentally used as paint with success.

Cutch.—According to Wynne (**1975**—11, 90), some of the highly ferruginous beds of the sub-nummulitic series, occurring near LAKHPAT (23° 50′ : 68° 50′), are used as pigments. The white shales from the same series and the Jurassic formation are used as whitewash (**B.** 418).

Kathiawar.—Adye (**11,** 209) has described deposits of yellow ochre occurring about 2 miles to the S. W. of HARIAWAR (22° 9′ 30″ : 69° 25′ 30″) in Navanagar State. The beds are from 6 ins. to 2 ft. in thickness.

Rewa Kantha (Rajpipla).—Deposits of red and yellow ochre are found at various places in the Jhagadia and Valia Taluks, according to Bose (**173**—23, 184). The best are those occurring at PADVANIA (21° 41′ : 73° 18′), which have been worked for many years. About 120 tons are said to be taken away annually by Mahomedan traders. A sample of the red ochre contained :—Fe_2O_3=23·80 : Al_2O_3=21·30 : SiO_2=35·32 per cent., with small quantities of lime and magnesia.

BURMA.

Myingyan.—A deposit of yellow ochre reported as occurring at PANBÉ (20° 50′ : 95° 5′) was found on examination by Hayden

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(*see* Oldham, **1324**—52, 6) to be variable in thickness, with a maximum of 30 feet.

Tavoy.—Mason (**1185**—1, 42) mentions an extensive bed of red ochre near KALLIAUNG (? KA-LEIN-AUNG, 14° 22′ : 98° 12′) on the Tavoy R. It is also said to be found on the Great Tenasserim R. (**B.** 418).

CENTRAL INDIA AGENCY.

Panna.—Some of the ochreous clays associated with ferruginous laterite are used, according to Vredenburg (**1854**—18, 314), as pigments. During the years 1909 to 1912 inclusive the deposits of yellow ochre yielded an average of 345 tons annually (**862,** 280).

CENTRAL PROVINCES.

Balaghat.—Red ochre is mentioned in the Central Provinces Gazetteer (**690,** 18) as being obtained in the SALITIKRI HILLS (21° 47′ 80° 52′), and used for colouring houses and dyeing the clothes of particular castes. Wilkinson (**1933**) also reports its occurrence in large quantities at SUKEINDAN, in the Lariki hills, a locality not marked on the maps (**B.** 417).

Chanda.—Wilkinson (**1933**) states that yellow ochre is found in abundance in the district, and brought to Nagpur, but gives no precise localities (**B.** 418).

Drug.—Red ochre of good quality is obtained from pits in the GANDAI (21° 40′ : 81° 10′) and THAKURTOLA (21° 39′ : 81° 2′) zemindaries (**B.** 417).

Jubbulpore.—The semi-ochreous hematites mentioned under the heading **IRON,** occurring at JAULI (23° 23′ 30″ : 80° 17′ 30″), have been quarried for many years (*see* Oldham, **1326**—71, 9) by Messrs. Olpherts & Co. for the manufacture of paint. The material is prepared for market by grinding to an impalpable powder between millstones worked by small water-wheels, and mixing with linseed oil. An addition of resin, dissolved in the oil, is said to give brilliance and durability to the colour. The outturn varies between 200 and 400 tons annually (**B.** 417).

A brief account of the industry has been given by Holes (**858**—1, 22). Picked samples of the hematite are said to yield 69 per cent. of iron.

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Nagpur.—Wilkinson (**1933**) states that yellow ochre, of somewhat inferior quality, is quarried near KALMESHWAR (21° 14′ : 78° 59′).

MADRAS.

Arcot (N.).—A general description of the deposits of yellow ochre found in the Madras Presidency has been compiled by Hunter (**894**—3). A bed nearly 2 ft. in thickness, occurring near TILAVERAM, at the foot of the NAGARI HILLS (13° 23′ : 79° 40′), is specially mentioned.

Arcot (S.).—Blanford (**147**—8, 214) mentions a bed of yellow ochre occurring among the Cuddalore sandstones at TRIVANDIPURAM (11° 45′ : 79° 46′), which is used as a pigment.

Bellary.—Foote (**596**—39, 193) mentions some ochreous 'argillites' of rich red colour, and also of yellow in many shades, which appear to have been worked to some extent for pigments, occurring beneath an iron ore bed at the Adargani mine, a mile and a half W. of KUMARASWAMI TEMPLE (15° 1′ : 76° 37′). Immense quantities of earthy red hematite, which would yield an excellent paint if reduced to powder, were seen along the western base of the Ramandrug section of the Sandur hills.

Nilgiri.—Blanford (**147**—3, 237) suggests that beds of ferruginous clay, occurring near the church at OOTACAMUND (11° 24′ : 76° 47′), might be used for colouring purposes. The beds owe their origin to the decomposition of highly ferruginous gneiss (**B.** 417).

Trichinopoly.—Some of the highly coloured clays of Cretaceous age associated with beds of pipe clay exposed between TERANY (11° 6′ : 78° 56′) and KAURAY (11° 8′ : 78° 56′ 30″) might, in Blanford's opinion (**147**—8, 214), be used as pigments.

MYSORE.

Shimoga.—Slater (**1649**—11, 42) says that much of the lithomarge which is found in various parts of the Sorab and Sagar Taluks, beneath and passing into laterite, might be used as colouring matter on account of its freedom from grit and the variety of shades it affords. Yellow is the prevailing colour, but pink, salmon, brick red, and other shades also occur.

PUNJAB.

Kangra.—Griesbach (**708**—31, 59) mentions the occurrence, reported by Hayden, of large quantities of yellow ochre in recent

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deposits near DAUKSA encamping ground, on the RATANG R. (32° 13′ : 78° 5′) in Spiti.

RAJPUTANA.

Kishangarh.—A black slate occurring near KISHANGARH (26° 34′ : 74° 56′) has been used with success as a pigment on the Rajputana-Malwa railway (**862**, 279).

ONYX
OPAL } *see under* **GEM-STONES.**

ORPIMENT *see* **ARSENIC.**

PAINT, MINERAL *see* **OCHRE.**

PEAT.

ASSAM and BENGAL.

True peat is not known to occur in these provinces, but masses of decayed vegetation of a peaty description are found in the *jhils* of Sylhet and Cachar, the Brahmaputra valley, and Lower Bengal. A sample from NAZIRA (26° 55′ : 94° 48′) in the Sibsagar district of Assam, analysed by Tween, yielded C=13·4 : Vol.=20·6 : Ash=52·4 : Water=13·6 per cent. (**B.** 124).

Piddington (**1405**—61) has described the formation of a species of peat in the *jhils* of Lower Bengal. The principal plant concerned in its production is the wild rice *Oryza sylvestris*. It is used to some extent as a manure, but is not likely to afford a useful fuel (**B.** 123).

A section exposed in a tank at SEALDAH, in Calcutta, was described in 1864 by H. F. Blanford (**147**—12). At 20 ft. from the surface a bed of peat a foot thick was met with, overlying 10 ft. of clay with sand and tree stumps. The bed is said to be traceable over a wide area on both sides of the Hughli, but it is too impure to be used as fuel, even if its extraction were possible. A sample from 30 ft. below the surface at CHITPUR, analysed by Prinsep (**1436**—14, 435), yielded C=16·7 : Vol., including water =62·0 : Ash=21·3 per cent. (**B.** 122).

KASHMIR.

A sample of peat obtained by Falconer and analysed by Percy (*Metallurgy*, p. 205) gave C=37·15 : H=4·08 : O=23·48 : N=2·02 : Ash=33·27 per cent. The included water amounted to 10·40 per cent. (**B.** 123).

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MADRAS.

Nilgiri.—An elaborate report on the feasibility of using the peat of the Nilgiri hills in a condensed form as fuel on Indian railways was drawn up in 1871 by Wragge (**1969**—1). Numerous peat bogs are said to occur on the hills at elevations over 6,000 feet. No estimate of the total quantity available was made, but it is stated that the deposits are in places 30 ft. deep, and that one acre, 3 ft. in thickness, will supply 750 tons of dried peat. The peat was used as fuel in Ootacamund (**B.** 120).

NEPAL.

Beds of impure peat are of frequent occurrence, according to Medlicott (**1197**—39, 99). They were specially noted at the Katwaldar gorge (? 27° 24′ : 85° 15′) and near the surface of the uplands to the N. of Katmandu (27° 41′ : 85° 19′). The deposits are said to be thick, and pure enough to be used for burning bricks (**B.** 124).

UNITED PROVINCES.

Partabgarh.—In 1865 Ouseley (**1350**) forwarded specimens of peat from a *jhil* near the village of KINDAULI (25° 49′ 30″ : 81° 37′ 30″) to the Asiatic Society of Bengal. The deposit was said to be about 12 acres in extent, and from 1 to 5 ft. thick. On analysis by Tween the peat yielded C=16·5 : Vol. =34·7 : Ash=35·5 : Water=13·3 per cent. (**B.** 123).

PETROLEUM.

The occurrences of petroleum in the Indian region are restricted to the Tertiary formations lying on either side of the peninsula, in the Punjab and Baluchistan on the west, and in Assam and Burma on the east. No deposits of mineral oil have been recorded from the palæozoic and mesozoic rocks of the Himalaya, or from the Gondwana system in the peninsula. The general distribution of petroleum in India has been described by the following writers:—

1881. Ball (**71**—45, 124-154). A summary of the information available.

1886. Medlicott (**1197**—77). Gives a general account of the nature and origin of petroleum, and discusses its mode of occurrence in foreign countries and in India.

1887. Marvin (**1182**). An essay on the petroleum resources of the British Empire, with special reference to the oil fields of India.

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1890. Boverton Redwood (**1469**—1). Notes on the oil fields of Burma, Assam, the Punjab, and Baluchistan, with remarks on the nature and composition of the oil.

1894. Oldham (**1324**—47). A general account of the oil fields. The history of the experiment at Khattan in Baluchistan is specially dealt with, and a systematic survey of the areas likely to be oil-bearing is advocated.

1904. Evans (**555**—11). A brief summary of information regarding the distribution and production of petroleum in India.

1910. Murray Stuart (**1723**—8). A discussion, illustrated by experiment, of the conditions governing the deposition of mineral oil in argillaceous sediments.

1912. Cunningham-Craig (**402**). A general introduction to the study of the geological conditions leading to the accumulation of petroleum, with special reference to its mode of occurrence in Burma.

1913. Boverton Redwood (**1469**—2, 3rd Edn., Vol. I, 43-53, 158-159). A history of the development of the petroleum industry in India, with a brief account of the oil fields.

The production of crude petroleum in India increased from 89,295 metric tons in 1898 to a maximum of 1,114,680 metric tons in 1913, reckoning the metric ton as equivalent to 249 imperial gallons. By far the greater proportion of this output was derived from a single oil field, that of Yenangyaung in Burma. India now occupies the seventh place among the oil producing countries of the world, though the quantity produced amounts to little more than 2 per cent. of the total. During the year 1914 there was a slight decrease in output, to 1,041,537 metric tons; but there was a recovery in 1915 to 1,152,986 metric tons.

ASSAM.

The oil belt of Assam extends from the Dehing basin in the extreme north-east of the province along the outer flanks of the hill ranges forming the eastern border of the Brahmaputra and Surma valleys, to the islands off the coast of Arakan in the Bay of Bengal, a total distance of about 800 miles. In Assam the petroliferous beds are known as the 'Coal measures,' and appear at the surface as a discontinuous series of narrow, elongated domes, cropping out from beneath a group of upper Tertiary sandstones with fossilised wood. The inner boundary of these groups is marked by a great thrust fault, separating them from an older group of unfossiliferous shales

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which may include strata of Cretaceous as well as Eocene age. The 'Coal measure' or oil-bearing horizon may therefore be referred to the Miocene or Oligocene period.

A special memoir on the geological structure of the oil belt, with a descriptive account of the oil springs known to exist, has recently been compiled by Pascoe (**1369**—13). References to this work are denoted below by the letter **P.**

Cachar.—Seepages of oil are reported to occur at the following localities :—

BADARPUR (24° 52′ : 92° 37′). This is probably the oil spring mentioned by Jones (**956**—2, 283) as issuing near a hill called Arpin, opposite SILTEK (SHIALTEK, 24° 52′ : 92° 41′) on the Barak R. An experimental boring has been put down by the Badarpur Tea Co., but the result has not been recorded (**B.** 137 ; **P.** 310).

LARANG R. (25° 3′ : 92° 42′)
MASIMPUR (24° 52′.30″ : 92° 50′) } (**P.** 310).
SARASPUR HILLS (? 24° 45′ ; 92° 35′)

Khasi and Jaintia Hills.—Along the southern margin of these hills the Cretaceous and Tertiary rocks are bent over, forming a well marked isoclinal fold. The crest of the fold has been entirely removed by denudation, and no large accumulation of oil can be expected to occur. Seepages have been observed at the following localities :—

CHELA (25° 12′ : 91° 42′). Close to, and to the S. of the village (**P.** 310).

DHAMALIA valley (? 25° 14′ : 91° 25′).—(**P.** 311).

KHASIMARA (25° 12′ : 91° 35′). The oil here is said to be remarkably free from paraffin wax and to possess good lubricating power (**P.** 311).

At the foot of the Jaintia hills, further to the east, two small petroleum springs were discovered in 1901 by Bose (*see* Griesbach, **708**—34, 19) on the eastern feeder of the DONA R., about 8 miles to the E. of MULAGUL (25° 2′ : 92° 22′). The oil issues from fine grained Tertiary sandstones.

Lakhimpur.—The frequent occurrence of exudations of petroleum in connection with the coal seams of Upper Assam was noted in 1838 by Jenkins (**941**—2) and S. F. Hannay (**760**—1). In 1845 P. S. Hannay (**759**) carried out a search for asphalt along the base of the Naga hills, and enumerates a number of localities at which seepages of oil were found. These occurrences were also noted by

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Mallet (**1159**—9, 356) in the course of his survey of the Assam coal fields. More recent exploration has resulted in the discovery of a productive oil field at DIGBOI (27° 23′ : 95° 41′), now being worked by the Assam Oil Co.

The oil field covers an area of about 130 acres. The visible outcrops indicate that it occupies the crest of an asymmetric anticlinal dome with its longer axis directed from E. N. E. to W. S. W., overfolded towards the N. N. W. The productive wells are situated on the southern limb of the anticline, where the dip of the rocks is from 30 to 40 degrees. An oil sand crops out at the surface, but the principal supply is obtained from a lower sand between 1,400 and 1,700 feet from the surface. Gas always accompanies the oil, especially in the E. N. E. part of the field (**P.** 295).

An account of the methods adopted in the exploitation of the field has been given by Capito (**280**). In most of the wells the pressure of gas is sufficient to cause the oil to flow intermittently. Much trouble is caused by the clogging of the wells with solid paraffin, with which the oil is saturated. The wax, however, forms one of the most valuable constituents of the oil, being of fine quality, with a melting point of 135° F. A refinery has been erected on the field, the principal products being :—

	Average annual production 1909—1913.
Kerosene oil	1,855,766 gallons.
Jute batching and lubricating oil	350,638 ,,
Petrol	94,913 ,,
Wax (and candles)	1,870,827 lbs.
Sundry oils, including fuel oil	201,503 gallons.

The output of crude oil has increased steadily from 28,000 gallons in 1892 to 4,688,547 gallons in 1914. In 1915 the output was 4,550,150 gallons.

Successful wells have also been drilled by the Assam Oil Co. at BAPPA PUNG, situated about a mile to E. N. E. of the Digboi field. This field probably marks the crest of a second asymmetric dome, similar to but distinct from that of Digboi (**P.** 301).

Oil springs are known to occur at the following additional localities in this district :—

DEKHIA JULI (27° 17′ : 95° 29′). Oil seepages have been found in the hills bounding the Dekhia Juli Tea Garden. At Sial Ghar, about a mile and a half to the N. E., three or four outcrops of oil sand were seen in a small stream ; and beyond this, in the direction of Digboi, is a line of *pungs* or 'salt-licks' (**P.** 294).

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DISANG R. The occurrence of several petroleum springs near Borhat (27° 10′ : 95° 25′) was noted in 1838 by Jenkins (**941**—2). The most productive springs are situated in a tributary on the right bank of the river, draining the Hilika range. They appear to mark the crest line of an anticline, overfolded towards the north-west (**P.** 288).

HAPJAN (27° 12′ : 95° 26′). Plentiful indications of petroleum were found by Simpson (**1640**—8, 205) in a stream about three quarters of a mile to the S. of the Hapjan Tea Factory (**P.** 292).

HILIKA (27° 16′ : 95° 38′). A gas seepage is reported to occur on a stream which enters the Dihing R. close to the village (**P.** 306).

MAKUM (27° 18′ : 95° 41′). The existence of several seepages of oil, with an abundant discharge of gas, on the Makum R. was recorded in 1865 by Medlicott (**1197**—9, 415). Two years later borings were put down by Mr. Goodenough, a member of the firm of Messrs. McKillop, Stewart & Co., and a record of the results obtained was published by Hughes (**888**—15) in 1874. None of the borings reached a greater depth than 143 ft., and only one (No. 5, 82 ft. in depth) appears to have produced any considerable quantity of oil. The discharge from this was intermittent, amounting at times to 2,000 gallons a day. A further experiment made by the Assam Railways and Trading Co. in 1888-89, when one boring was carried to a depth of 500 ft., met with little success. A flow of 800 gals. a day was struck at a depth of 158 ft., but on deepening the hole to 500 ft. a strong flow of water stopped the oil. The locality appears to be worthy of further and deeper tests (**P.** 302).

Numerous oil seepages occur in connection with seams of coal on the NAMDANG R., about a mile and a half E. of the Makum area. The dips of the strata indicate that these springs may lie on the eastern extremity of a large dome which includes the latter area. A little oil was obtained from a boring put down by the Assam Oil Co., at 400 feet (**P.** 304).

NAHOR PUNG (27° 13′ 30″ : 95° 27′). Hannay (**759**, 818) mentions the occurrence of numerous oil seepages in this area. The structure of the rocks is obscure, but the springs are probably situated on the axis of a greatly denuded anticlinal dome. Borings put down here by Mr. Goodenough in 1866 proved unsuccessful, gas and a little oil only being met with (**P.** 292).

NAMCHIK or NAMRUP R. (27° 25′ : 96° 2′). A line of gas 'pungs,' showing traces of oil, was discovered here in 1837 by Major White (*see* Bigge, **125**—1; Griffith, **709**—4, 60, 117). The line is about 2 miles in length, and presumably coincides with the crest of an anti-

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clinal fold, striking east and west. The area would be worth testing (**P.** 306).

SUPKONG, marked as 'Sookhung' on Wilcox's map of Upper Assam, adjoining the village of PHAKIAL (27° 20′ : 95° 47′). Wilcox (**1926**—2, 415) describes two large gas 'pungs' close to the bank of the Buri Dihing at this place. Green petroleum was seen floating on the water near the edge of the springs (**P.** 309).

Nowgong.—MEYONGDISA R. Smith (**1657**—2, 85) noted the occurrence of several springs of soft blue mud, apparently caused by an escape of gas, about half a mile to the S. E. of the village of GUDU (25° 55′ : 93° 21′). The beds in which they occur probably belong to the 'Coal measure' group (**P.** 280, 310).

Sibsagar.—CHINGAN (26° 47′ : 94° 55′). Petroleum was observed by Mallet (**1159**—9, 358) exuding in four or five places from massive 'Coal measure' sandstones near the head of the Tiru R. (**P.** 287).

KANUGAON (27° 3′ : 95° 13′). An oil seepage was discovered by Mallet (**1159**—9, 358) on the bank of the Tiok R., issuing from the sandstones overlying the 'Coal measures' close to the boundary fault. Another seepage was observed by Hayden (**793**—18, 316) on the right bank of the river, about 2 miles lower down (**P.** 287).

TEL PUNG (26° 45′ : 94° 52′), on the Dikhu R. in the Nazira coal field. Exudations of petroleum were observed by Mallet (**1159**—9, 358) from a bed of massive fine grained sandstone striking across the river. The seepages occur on or near the crest of an elongated anticlinal dome, overfolded towards the north-west. The structure is not unfavourable to the existence of workable oil beneath the surface (**P.** 285).

Singpho Hills.—MIAOBUM (27° 27′ : 96° 21′). A feeble discharge of gas was observed by La Touche (**1034**—7, 112) in a small pool close to the outcrop of a seam of coal on the ascent to Miaobum, at an elevation of about 1,300 ft. above the Dihing valley. Several *pungs* or 'salt licks' occur in the vicinity (**P.** 308).

NCHONGBUM (27° 31′ : 96° 32′). Wilcox (**1926**—2, 415) mentions the occurrence of a 'pung' on the ridge between the Dungan and Dapha rivers, near the village of Kumku. According to La Touche (**1034**—7, 112), there is a copious discharge of gas from the spring, sufficiently strong to force up a jet of water about 8 ins. in height. The gas is inflammable, giving off an odour of burnt petroleum (**P.** 308).

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BALUCHISTAN.

Bolan Pass.—KIRTA (29° 36′ : 67° 31′). Traces of petroleum were observed by Oldham (*see* King, **987**—46, 5) in travertine deposited by hot sulphurous springs at the foot of the hills to the W. of the dak bungalow. A boring sunk in 1889 was carried to a depth of 360 ft., when a copious spring of hot sulphurous water was struck, accompanied by a little oil.

Kachhi.—Vredenburg (**1854**—36, 208) states that petroleum springs have been reported as occurring among the Siwalik strata surrounding the Kachhi plain, and that the structure of the rocks in places seems favourable to the storage of oil. A seepage is reported by Hutton (**900**—8, 564) to occur in the sulphur mines at SANNI (29° 9′ : 67° 37′), where the oil was collected and boiled down with the refuse of the mines to form a dark coloured brimstone (**B.** 126).

LAS BELA.—The existence of groups of mud volcanoes, described by Robertson (**1495**), Hart (**777**, 330), and Stiffe (**1764**—2), on the Mekran coast in the neighbourhood of RAS KACHARI (25° 24′ : 65° 48′), indicates the presence of gas under pressure in the underlying strata. According to Vredenburg (**1854**—36, 206), the beds are the same as those from which the mineral oil of Persia is derived, and they correspond in geological age with the oil-bearing strata of Burma, and with the 'Schlier' of Europe. The rock structure is said to be ideally suited for the accumulation of mineral oil. The left bank of the Hingol R. to the N. E. of AGHOR (25° 27′ : 65° 28′) is suggested as a favourable site for an experimental boring. The mud volcanoes are said by Stiffe to occur at intervals along the coast as far as GWADUR (25° 7′ : 62° 19′), about 200 miles to the W. of Ras Kachari.

A sample of gas from one of the volcanoes, examined by Christie (**314**—2), was found to contain members of the paraffin series with a higher carbon content than marsh gas, indicating the possibility of its association with liquid hydrocarbons below ground.

Sibi.—HARNAI VALLEY. In the year 1889 a survey of the country lying to the east of the Sind-Pishin railway, in the Harnai valley, was undertaken by Oldham (**1324**—31; —32), with the special object of discovering the most favourable sites for petroleum exploration. The lower Tertiary rocks in this area are thrown into a series of well marked anticlinal domes. Indications of the existence of petroleum under pressure were detected in fissures and in veins of calcite traversing the massive Eocene limestones which form the crowns of the

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domes; but borings put down at the sites selected failed to meet with any accumulation of oil (*see* King, **987**—49, 9).

KHATTAN (29° 34′ : 68° 31′). The conditions under which petroleum occurs at this place have been fully described by Townsend (**1794**—1; —2) and Oldham (**1324**—32, 104; —47, 147). Here the exposed end of an anticlinal dome, similar to those seen in the Harnai valley, is greatly shattered by faulting; and small quantities of petroleum, accompanied by sulphurous water, issue from fissures in the rocks forming the 'cover' of the dome. Borings were put down between the years 1884 and 1890, and oil was met with at depths varying from 62 to 374 feet. The oil is described as a black, tarry, viscid substance, which becomes semi-solid at temperatures below 60° F. It occurs only in crevices in the rock, and the supply was never very large. In 1889 it amounted to 218,490 gallons. The admixture of sulphurous water rendered the oil difficult to distil, but it was used with success on the North-Western railway as locomotive fuel, and in the Khojak tunnel works (*see* Hughes, **884**).

BENGAL.

Chittagong.—The rocks forming the hill range lying to the N. of Chittagong correspond in geological age with those of the Assam oil belt, and are thrown into a well marked and slightly asymmetric anticlinal fold. No indications of oil are visible at the surface, but seepages of inflammable gas have long been known to exist along the crest of the anticline between SITA-KHUND (22° 38′ : 91° 45′) and KUMIRA (22° 31′ : 91° 47′). Trial borings recently put down in this area have not yet succeeded in reaching oil in quantity, though in one of them traces were met with at depths of about 840 and 1,800 feet, and strong flows of gas at deeper horizons (**P.** 311).

BOMBAY.

Sind.—The possibility of finding oil at SUKKUR (27° 42′ : 68° 55′) on the Indus R., where the upper Eocene (Khirthar) limestone overlying the coal and oil-bearing horizon in Baluchistan is brought to the surface by a gentle anticlinal fold, was suggested by Medlicott (**1197**—77, 202) in 1886. A boring put down in 1893-95 near the crest of the anticline to a depth of about 1,600 feet proved unsuccessful, no indications of petroleum being found beyond faint traces of gas at 785 feet. The rocks passed through beneath the Khirthar limestone consisted of gypseous shales with occasional thin bands of concretionary limestone. No beds of a sandy nature, in which oil might accumulate, were met with (*see* La Touche, **1034**—23; Griesbach, **708**—29, 6).

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BURMA.

Two distinct oil-bearing regions are known to occur in Burma, separated from each other by the mass of hill ranges known collectively as the Arakan Yoma, which forms the western margin of the Irrawaddy valley. One of these areas, by far the less important from an economic point of view, comprises a number of islands in the Bay of Bengal lying close to the coast of Arakan, and may be considered as an extension, to the south of Chittagong, of the Assam oil belt. The other, or Burmese oil belt, is a narrow strip of territory extending along the valleys of the Irrawaddy and its tributary the Chindwin for a known distance of about 400 miles. The productive oil fields are confined at present to isolated portions of a section of the belt about 90 miles in length.

A general report on the geology and economic resources of the Burmese oil belt was drawn up by Noetling (**1311**—27) in 1897, when the exploitation of the oil fields, thrown open to British enterprise by the annexation of Upper Burma, was still in an early stage of development. This work has now been supplemented and superseded by an exhaustive memoir, dealing with the whole of the province, compiled by Pascoe (**1369**—11). References to the latter publication are denoted below by the letter **P.**

The principal source of petroleum in Burma is a sub-division of the Tertiary system to which the name 'Pegu group' was given by Theobald (**1763**—16, 268). This consists almost entirely of rapidly alternating, lenticular bands of clay, sandstones of varying degrees of hardness and porosity, and impure limestones containing a marine or estuarine fauna of Miocene age. The sandy beds afford storage ground for the oil, which is held in place by the 'cover' of impervious clay. The thickness of the formation is uncertain, but probably amounts to 10,000 feet or more where it is fully developed. The whole series of beds has been thrown into more or less pronounced undulations, often taking the form of anticlinal domes, not greatly disturbed by faulting; so that favourable conditions exist for the accumulation of oil in subterranean reservoirs or 'pools.' The distribution of oil is capricious. Many of the sands, though otherwise favourably situated, are found on being tested to be filled with water, or in some cases with gas alone. Water-bearing sands are occasionally met with occupying an intermediate position with regard to the oil sands above and below; a circumstance which indicates that no migration of oil from the more deeply seated to higher horizons can have taken place, and that the oil has originated in the beds which now contain it.

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At certain places oil has been found exuding from Eocene (nummulitic) beds underlying the Pegu series; but these occurrences are usually of a feeble character and, except in Arakan, of little commercial importance.

ARAKAN area.

Akyab.—BARANGA Is. These islands, three in number, are composed of sandstones and shales, probably of nummulitic age, sharply folded in a N. N. W.—S. S. E. direction. About 40 wells have been put down near the southern extremity of the eastern island. These formerly produced from 100 to 120 gallons of oil a day in all, but of late years the yield has steadily declined. The oil is obtained from a depth of about 300 feet.

Small quantities of oil have also been obtained from wells on the middle and western islands, where oil seepages and gas vents occur at several places (**P.** 198).

KRINKHWAIMAU (20° 19′ 30″ : 93° 3′). Small quantities of gas and oil are found in several places among the hills between the mouths of the Kaladan and Kywegu rivers, to the N. E. of the village. The oil is burnt extensively in Akyab (**P.** 199).

NATARAN (20° 55′ : 92° 58′). Burkill has reported the occurrence of an oil spring on the Pi Kyaung, not far from this village (**P.** 199).

The average annual output of petroleum from this district, during the five years 1909 to 1913, amounted to 19,259 gallons, as against 40,101 gallons in the previous quinquennial period. About 13,000 gallons were produced in 1914, and 12,000 gallons in 1915.

Kyaukpyu.—RAMRI and CHEDUBA Is. The earliest accounts of the occurrence of petroleum in these islands were given by Foley (**595**—3, 28) in 1835, and by Halstead (**742**, 21) and Bogle (**165**—1) in 1841. In Cheduba the oil was collected by the primitive method of skimming the surface of pools of water with a slip of bamboo; but in Ramri wells were sunk into the oil bearing strata to a depth in some cases, of 50 or 60 feet, and the oil percolating into these was baled out twice a day. The yield obtained in this way was trifling, not more than 6 gallons or so a day from the most productive wells. The same methods were still being practised in 1878, when they were described by Mallet (**1159**—14, 211), who also gives a list of all the oil seepages known to occur in the islands.

The mud volcanoes or 'salses' which also occur in these islands were fully described at the same time by Mallet (**1159**—13), and shown to have no connection with true volcanic phenomena, but to be due to the escape of gas and the lighter hydrocarbons, which occasionally takes place with extreme violence. Paroxysmal eruptions

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of this kind have been described by Williams (**1934**, 1—3); Russell (**1535**), Hankin (**757**), Howe (**878**), Weston (**1914**) and Mallet (**1159**—16; —22; —26; —34; —39; —43; —44; —47; —50). Several more recent eruptions have also been recorded by Coggin Brown (**211**—1; —4; —6; —7).

The rocks are almost always highly inclined or vertical, often exhibiting an abrupt variation in strike. They appear to form a single series consisting of shales and sandstones, with limestones in which nummulites have been detected at one or two places. A consideration of the facts has led Pascoe (*see* La Touche, **1034**—39, 98) to the conclusion that the rocks are thrown into closely compressed folds, and that the crests of the anticlines have been sufficiently denuded to leave an uninterrupted series of steep dips. The sinuosity of strike is accounted for by the supposition that a predominant system of N. N. W.—S. S. E. folds has been impressed upon a previously existing E.—W. system. The distribution of the gas vents, which presumably mark the position of anticlinal crests, indicates that five distinct folds occur on a cross section of Ramri I. (**P.** 185).

Oil is obtained from two fields, both situated in Ramri I.:—

Minbyin or Yenandaung (19° 12′ : 93° 39′). Several wells were drilled here by the Australian and Baronga Oil Cos. about the year 1880 (*see* Robertson, **1499**, 230); but the yield, though at first encouraging, gradually diminished and the industry is now in the hands of the natives, who have adopted a simplified form of the Canadian system of drilling. The productive wells lie along two parallel bands about 300 yards apart, probably corresponding to the position below ground of a single oil sand, situated on either side of a denuded anticlinal crest. The bulk of the oil is obtained from depths between 250 and 300 feet. The average production of each well is probably less than 2 gallons a day. About 400 have been drilled, but nearly 300 of these have been abandoned (**P.** 190).

Ledaung (19° 5′ 30″ : 93° 47′). The oil occurs here on two parallel lines as in the Minbyin field. Fifteen or twenty wells have been drilled to a depth of probably not more than 100 feet (**P.** 192).

The Minbyin oil is darker in colour and heavier than that of Ledaung, having a specific gravity of 0·880 as against 0·756. An oil of intermediate grade, sp. gr. 0·802, occurs at Kyaukpyauk (19° 16′ : 93° 36′ 30″). The oil is very pure, contains little paraffin, and is used locally in its crude state (**P.** 191).

The production of these oil fields, never very large, has gradually declined in late years. For the five years 1904 to 1908 the average was 59,972 gallons, and in the succeeding quinquennial period 36,027

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gallons annually. In 1914 the output fell to 25,987 gallons, and again to 23,220 gallons in 1915.

II. BURMESE oil belt.

Chindwin (Lower).—BAWDIBIN (22° 37′ : 94° 42′). An asymmetric anticlinal fold, forming the Mahodaung range of hills, has been traced in an almost due N. and S. direction from near KIN (22° 47′ 30″ : 94° 43′) on the Chindwin, to the neighbourhood of NYAUNG-BINHLÉ (22° 19′ : 94° 41′ 30″), a distance of about 45 miles (Dalton, **409**, 617). The rocks consist of limestones and limestone conglomerates, probably belonging to the Pegu series, and are highly inclined or vertical to the east of the crest line, which runs along the eastern flanks of the range. Seepages of oil, in some cases accompanied by gas, occur in twelve of the streams draining the eastern slopes. Two wells drilled by the Burma Oil Co. close to the crest failed to meet with oil in paying quantities (**P.** 141).

TAUNGDWIN KYAUNG (22° 41′ : 94° 22′). An oil well and hot spring are marked in this position on the quarter inch Frontier map of Burma (**P.** 146).

Chindwin (Upper).—Oil seepages, apparently situated on the same structural line as the Taungdwin spring, are reported by Noetling to occur at INDIN (23° 1′ 30″ : 94° 7′) and YENATHA (23° 12′ 30″ : 94° 14′). Gas and oil were also seen issuing at YENAN VILLAGE (23° 57′ : 94° 32′) from an anticlinal fold in the 'Prome stage' of the Pegu series (**P.** 146).

Henzada.—Stuart (**1723**—9, 259) discusses the prospects of obtaining petroleum in this district, and calls attention to the fact that the upper members of the Pegu series, which constitute the chief petroliferous horizon in Upper Burma, are absent. Several groups of mud volcanoes occur in the district, but according to Stuart, they are all situated on faults, not on the crests of folds. The gas issuing from the vents is apparently derived from underlying nummulitic beds. No oil is associated with it.

Traces of oil were reported by Blanford (*see* Theobald, **1763**—16, 346) to occur at YENANDAUNG (18° 12′ : 95° 11′); but Theobald and Stuart found only a copious discharge of gas at this locality (**P.** 177)

Magwe.—MIGYAUNGÉ-KYUNDAW anticline (19° 52′ : 95° 11′). Surveyed by Sethu Rama Rau (*see* Hayden, **793**—26, 78) in 1911. The anticline is approximately symmetrical, with shallow dips ranging from 10 to 25 degrees. The Pegu beds are continuous with those of

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the Minbu oil field. Conditions for the accumulation of oil are regarded as favourable.

ONDWÉ (20° 6′ 30″ : 95° 11′). An inlier of Pegu beds was discovered and mapped by Sethu Rama Rau (*see* Pascoe, **1369**—8) in 1909. The beds form an elliptical area about 4 miles in length and 1½ mile broad, at the centre of an anticlinal dome. The prospects of obtaining oil here are considered favourable, though no seepages were found (**P.** 138).

WETCHOK-YEDWET anticline (20° 26′ : 95° 16′). This inlier of Pegu beds has been fully described by Pascoe (**1369**—7). The outcrop is about 14½ miles in length, with a maximum width of 4½ miles. The dips are low, and the thickness of beds exposed not more than 300 feet. The structure is considered to be eminently suitable for the storage of oil, but no seepages were observed (**P.** 137).

YENANGYAUNG (20° 27′ 30″: 94° 55′). The oil field known by this name is situated about 2 miles to the E. of the Irrawaddy R. at Yenangyaung. The inlier of Pegu beds, of which it forms the centre, is about 6 miles in length, with a maximum width of a little over a mile, but the productive area does not cover more than 1½ sq. mile. The beds form a symmetrical, elongated dome, the longer axis of which lies in a N. N. W.—S. S. E. direction, but indications exist of an earlier, transverse system of folds, which causes some irregularity in the pitch of the anticline at more than one place. Faults of small throw, connected with this double system of folds, are numerous, but do not affect the productiveness of the field (**P.** 66).

The "earth-oil" industry here, under Burmese rule, was vested in the hands of 24 families, known as *Twinzayos*, whose operations did not extend to a greater depth than about 300 feet; the supply being drawn from three, or perhaps four oil sands, lying at depths of approximately 80, 150, and 220 feet from the surface (Noetling, **1311**—27, 111). The oil sands are reached by timbered shafts, 4 or 5 ft. square, from which the oil is baled out in earthen jars or in wicker baskets covered with lac. Particulars of the method of sinking the wells, the conditions of tenure and of labour, with estimates of the number and yield of the wells, have been given at various times by the following writers:—

(*N.B.*—The viss =3·65 lb., and 100 viss are taken as equivalent to 42 gallons.)

1795. Symes (**1738**—1, 441;—2). Estimated output 90,900 tons. Describes the topographical features of the locality.

1797. Hiram Cox (**382**). A very complete account of the industry. Estimated number of wells, 520. Total

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production, 56,940,000 viss, =23,914,800 gallons. These figures are probably overstated.

1826. Crawfurd (**386**—3, 53). Maximum number of wells, 400. Average yield of each, 230 viss, =97 gallons. Total yield, calculated from the average number of boats engaged in the oil traffic, 17,568,000 viss, = 7,378,560 gallons. Another estimate, calculated from the revenue derived from the wells, amounts to 22,000,000 viss,= 9,240,000 gallons.

1855. Yule (**1987**—4, 19). Number of producing wells, about 130. Total annual yield estimated at 7,154,000 viss, =3,004,680 gallons.

1855. Oldham (**1326**—17, 312). Two estimates of the total yield are given. The first, on the assumption that 200 wells are productive, amounts to 10,260,000 viss, = 4,309,200 gallons. The second, calculated from the number of carts employed in carrying the oil to the river, amounts to 4,500,000 viss, =1,890,000 gallons.

1873. Strover (**1721**, 14). Estimated total yield, 6,000,000 viss, =2,520,000 gallons.

1879-1881. Noetling (**1311**—9, 14; —27, 244). From information supplied by one of the Burmese Ministers to the Chief Commissioner, it appears that there were at this time 264 productive wells at Yenangyaung, and that the monthly yield was 386,000 viss, or 4,632,000 viss, =1,945,440 gallons annually.

1884. Romanis (**1511**—8). No estimate of the total yield is given, but it is said that 130 cart loads of 150 viss each represent the accumulation of five days' working. As compared with the estimate calculated on a similar basis by Dr. Oldham, this would mean a considerable reduction in the total output.

1889. Noetling (**1311**—1). An elaborate analysis of the records of production of each native well, preceded by remarks on the geology and physical characters of the field. The number of productive wells is stated to be 281; and the maximum daily output from all the wells is estimated at about 20,000 viss, =8,400 gallons.

Statistics quoted by Noetling (**1311**—27, 244) and Pascoe (**1369**—11, 76) show that the production from native wells gradually increased from about 2½ million gallons in 1888 to 8½ million gallons in 1900. During the next eight years there were slight fluctuations in the output; but since the year 1908 there has been a rapid decline,

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mainly owing to the sale by the *Twinzayos* of their well sites to drilling companies. The use of a simple form of diving dress, which enables the well sinkers to work in the atmosphere of gas at the bottom of the wells, and to carry them to depths of more than 400 feet, accounts for the increase in production in previous years.

The operations of the *Twinzayos* are confined to two separate petroliferous tracts, covering respectively 295 and 155 acres, and lying to the north and south of the centre of the anticlinal dome, near the villages of TWINGÔN and BEMÉ. Their rights had been recognised by Government on the annexation of Upper Burma in 1886, and the exploitation of the field by means of drilled wells, begun by the Burma Oil Co. in the following year, was at first restricted to the area known as KHODAUNG, lying between these reserves. At the time of Noetling's survey few of the drilled wells had penetrated below the oil sand worked by the *Twinzayos*, and the deepest of them yielded no oil, though it was carried to 1,011 feet. From 1896 onward, however, rich supplies of oil were obtained from other wells over 700 ft. in depth, and since then the development of the field has proceeded without interruption. The existence of productive sands has been proved to depths of over 2,000 feet, but these have as yet been only slightly drawn upon. In addition to the Burma Oil Co., four other companies are now engaged in drilling on the Twingôn and Bemé reserves, having purchased sites from the native owners. Their advent has resulted in a race for the deeper oil sands, which is not in favour of a systematic exploitation of those lying nearer the surface, and has in some cases led to their permanent injury by flooding them with water. Steps have been taken, by the appointment of a Warden of the oil fields, assisted by an Advisory Board nominated by the Companies, to mitigate as far as possible these and other evils due to excessive competition (*see* Holland, **859**—71, 48).

Accounts of the development of the petroleum industry under modern conditions have been given by Davidson (**429**) and Cholmeley (**312**).

The earliest scientific accounts of the nature and properties of Yenangyaung petroleum, or 'Rangoon Tar' as it was called, were published in 1831 by Christison (**315**) and Gregory (**705**). From the crude oil a crystalline substance was obtained, to which the name 'petroline' was given. This was afterwards recognised by Christison (**315**, 123) as identical with 'paraffin,' previously described by Reichenbach. Further investigations regarding the characters and chemical composition of the crude petroleum have been carried out by the following observers :—

1856. de la Rue and Müller (**458**). In addition to 10 or 11 per cent., of paraffin, the oil was found to contain the

hydrocarbons Benzene (C_6H_6), Toluene (C_7 H_8), Xylene (C_8 H_{10}), and Cumene (C_9 H_{12}).

1861. Tomlinson (**1790,** 299). A brief summary of information regarding the nature and properties of the crude oil.

1865. Warren and Storer (**1890**). Results of the fractional distillation of a sample of Burmese petroleum. The following constituents were isolated:—Rutylene (C_{20} H_{20}), Margarylene ($C_{22}H_{22}$), Laurylene ($C_{24}H_{24}$), Cocinylene ($C_{26}H_{26}$), and Napthalene (C_{20} H_8). Indications of the presence of Pelargone, Xylene, and Isocumene were also detected.

1891. Holland (**859**—3, 251). Results of analyses of 8 samples of the crude oil:—

—	Depth of well feet.	Specific gravity at 60° F.	Proportion of illuminating oil, approx.	Flashing point of illuminating oil.
A. KHODAUNG . .	727	0·8852	15 per cent.	74° F.
B. „ . .	727	..	14 „ „	75° „
C. „ . .	359	0·889	14 „ „	73° „
D. TWINGÔN . . .	310	0·873	17 „ „	75° „
E „ . . .	195	0·875	18 „ „	76° „
F. „ . . .	280	0·882	18 „ „	74° „
G. BEMÉ . . .	100	0·897	very small quantity.	
H. „ . . .	100	0·902	7 „ „	79° „

All the samples contained large quantities of solid hydrocarbons. Four contained free sulphuretted hydrogen, and varying, though small, amounts of sulphur were found in all.

1894. Engler (**549**). Samples from Khodaung and Twingôn gave the following results on distillation:—

—	KHODAUNG		TWINGÔN.	
	Percentage by volume.	Sp. Gr.	Percentage by volume.	Sp. Gr.
Light oil . . .	4·3	0·755	5·5	0·755
Illuminating oil . .	38·8	0·849	38·8	0·843
Lubricating oil and paraffin wax.	50·4	0·895	48·7	0·888

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The oils are said to consist chiefly of the C H_{22} group, with only small quantities of napthenes.

The crude oil is usually of a dark green colour by reflected light, and reddish brown by transmitted light. It possesses a decidedly aromatic odour. The shallower sands produce a heavy oil, valuable as a lubricant, of sp. gr. 0·95 to 0·98; but the specific gravity decreases with depth to as low as 0·80. Formerly the heavy oil was in considerable demand, under the name of 'Rangoon oil,' for cleaning small arms. It was also imported by Messrs. Price & Co. for the manufacture of candles (*see* Barlow, **76**). The paraffin wax, which exists in the oil in the proportion of 12 to 14 per cent., is now extracted at the refineries in Rangoon, and largely made into candles on the spot.

The average annual production of the Yenangyaung oil field, during the five years 1909 to 1913, amounted to 181,772,785 gallons, or nearly double the average of the previous quinquennial period, which was 93,856,622 gallons. In 1914 the output amounted to 174,981,799 gallons, and in 1915 there was an increased production of 198,809,315 gallons.

Meiktila.—LEBYA (21° 0′: 95° 33′ 30″). A dome-shaped inlier of Pegu beds here has been examined and mapped by Cunningham Craig, and a shallow well was drilled by the Burma Oil Co. without finding oil (**P.** 138).

Minbu.—MINBU (20° 11′: 94° 53′). Close to the town of Minbu, the crest line of an acute anticlinal fold is marked by a group of mud volcanoes and gas pools, which appear to be situated upon a fault crossing the fold obliquely at this point. Descriptions of these phenomena were given by Oldham in 1855 (**1326**—17, 339) and by Noetling (**1311**—27, 81), who has recorded in minute detail the character of each of the vents, and the changes in them that took place during an interval of seven years, between 1888 and 1895. Small quantities of petroleum are usually mixed with the mud and water ejected from the vents.

The acute flexure has been traced in a S. S. E. direction from a point about 2 miles to the N. of Minbu,—where it disappears under a covering of alluvium,—for a distance of about 14 miles to the south of the town. Beyond this, the arch flattens out and becomes merged in a broad expanse of Pegu beds. Towards the south the fold becomes doubled, a subsidiary flexure being developed along the eastern side of the crest. The main flexure is asymmetric, slightly overfolded on the eastern side, and very narrow in proportion to its length, so that the area in the immediate vicinity of the crest available

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for the storage of oil is strictly limited. The crown of the arch has been deeply denuded, and the removal of the 'cover' has not only permitted much of the oil to drain away from the sands, but has also caused these to become flooded with water (**P.** 149).

In a recent paper (**154**—5), Bleeck has discussed the evidence afforded by a number of test wells sunk at various points along the flexure. These have shown that the prospects of obtaining an abundant supply of oil are not promising, owing to the contracted nature of the oil pools, the barrenness of many sands which appear to be favourably situated for the storage of oil, and the heavy asphaltic character of the oil itself, which causes it to mix readily with water. It is probable that the quantity of oil primarily existing in the strata comprised in this field was not large.

The production from the Minbu oil field rose from 18,320 gallons in 1910 to 3,896,365 gallons in 1912. During the succeeding three years, the average production has amounted to 2,399,236 gallons annually.

NGAHLAINGDWIN (20° 41′ 30″ : 94° 25′). An oil seepage and two Burmese wells are situated about 3 miles to N. by W. of the village, on the crest of an asymmetric anticlinal fold, which at this point pitches steeply to S. S. E. In this case, the western limb of the anticline shows a steeper dip than the eastern. About 9,000 feet of Pegu beds are exposed on the eastern side of the crest (**P.** 148).

Another oil seepage occurs about $3\frac{3}{4}$ miles to S. W. by W. of Ngahlaingdwin, and half a mile E. of the Nwamadaung range. The rocks here are probably of nummulitic age (**P.** 149).

NGAPÉ (20° 4′ : 94° 30′). A large area lying to the E. of the town, occupied partly by beds of the Pegu series, and partly by the underlying Eocene formation, has been described by Cotter (**372**—6). No indications of an anticlinal structure were observed, but oil seepages were seen at three places. Two of these, near PEINHNEBIN (20° 5′ : 94° 34′), issue below the boundary of the Eocene rocks with the Pegus; and the third from Pegu strata near KYETU-BOK (19° 59′ : 94° 40′). The prospects of oil being found in paying quantities in this area are very poor (**P.** 168).

Myingyan.—GWEGYO (20° 48′ : 95° 4′). An inlier of Pegu beds, forming the Gwegyo hills, was surveyed in 1897 by Grimes (**712**, 68), and found to consist of a long, narrow anticlinal fold, probably asymmetric, and dislocated by a fault or series of faults along a line nearly coinciding with the crest. The northern part of the anticline has since been described in greater detail by Pascoe (**1369**—3), and the southern by Cotter (**372**—4). The inlier is

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about 23 miles in length, with a maximum width of 2¼ miles. Except at either extremity of the inlier, in the north near TETMA, and in the south in the area known as the PAYAGYIGÔN-NGASHANDAUNG oil field, the faults have entirely obliterated the eastern limb of the fold. Any attempt to explore the central part of the inlier by drilling would therefore be admittedly speculative, since it is impossible to determine beforehand the position of any portion of the subterranean arch that may have remained unaffected by the faults. Test wells drilled in the Tetma and Payagyigôn-Ngashandaung areas have shown disappointing results, though one well in the latter area yielded 10 barrels of oil in the first 24 hours (**P.** 124).

KABAT or SATTEIN (21° 3′ : 95° 19′). The structure of an inlier of Pegu beds, lying to the E. of the village, has been described in a special report by Pascoe (**1369**—1). The beds are brought up by an asymmetric anticlinal fold, the eastern limb of which has the steeper dip. The crest line runs in a N. N. W.—S. S. E. direction about half a mile to E. N. E. of Kabat. Three test wells drilled by the Burma Oil Co. met with gas under considerable pressure and a slight show of oil in one well. Indications of a second anticline are visible to the east of the Kabat fold (**P.** 134).

PAGAN (21° 10′ : 94° 56′). Grimes (**712**, 66) has described a Pegu inlier forming a range of hills extending from a point about 5 miles S. E. of Pagan for about 14 miles to S. S. E. The anticlinal fold which brings up these beds is probably a continuation northwards of the Gwegyo anticline, and exhibits a similar structure, being asymmetric and faulted along the crest line. No seepages of oil have been observed. Two test wells drilled by the Burma Oil Co. were without result (**P.** 134).

SINGU (20° 56′ 30″ : 94° 54′). This oil field is formed by a prolongation southwards of the Yenangyat fold (*see* **Pakokku**, *below*), and corresponds to a distinct rise in the crestline of the anticline, which reaches a maximum near the hill Moksoma Kon, about 2½ miles to S. S. W. of the town. Grimes (**712**, 53) considered the conditions existing here to be very promising. A rich oil sand has been met with in the neighbourhood of the maximum elevation of the crest at depths between 1,400 and 1,450 feet, and at greater depths in adjoining areas. A second oil sand has been proved at a depth of 1,800—1,900 feet, but has hitherto been little worked, being treated by the Burma Oil Co. as a reserve source for their refineries (**P.** 114).

The average annual production from this oil field, during the five years 1909 to 1913, was 47,888,382 gallons. During the two succeeding

years the output has increased from 73,409,518 gallons in 1914 to 77,005,880 gallons in 1915.

TAUNGTHA HILL (21° 18′ : 95° 30′). An inlier of Pegu beds, forming a range of hills about 6 miles in length culminating in Taungtha hill, has been described by Cotter (372—3). The structure consists of an elliptical dome, strongly asymmetric, with steep dips on the western side, and seriously dislocated by faulting and contortion. There are no surface indications of petroleum. The prospects of obtaining oil by drilling are considered to be very poor.

WELAUNG (21° 9′ : 95° 26′). This anticline lies 6½ miles to E. N. E. of the Kabat fold. A deep boring was put down by the Burma Oil Co. without result (P. 137).

Pakokku.—A range of hills on the west side of the Yaw R. probably corresponds with an anticlinal fold extending due N. and S. for many miles. Oil seepages have been reported to occur near the villages of MAN (21° 23′ : 94° 19′ 30″), YEBYU (21° 34′ 30″ : 94° 24′), and KYIN (21° 38′ : 94° 19′). These areas are too far from the known oil belt and too close to the axis of the Yoma range to be of much value (P. 140).

KYAUKSWÉ (21° 9′ : 94° 15′ 30″). Dalton (409, 615) mentions the occurrence of gas vents to the S. E. of the village, in beds containing much carbonaceous matter (P. 140).

KYAUKWET (21° 40′ : 94° 44′) and SUWIN (21° 41′ : 94° 41′). Oil seepages occur near these villages, on an anticlinal fold bearing the same relation to other tectonic lines as that of Yenangyat-Singu. There is said to be considerable disturbance of the strata, and the prospects of obtaining oil are not good. Parts of the area have been tested by the Indo-Burma Petroleum Co. (P. 139).

MYAING (21° 37′ 30″ : 94° 54′). An inlier of Pegu beds has been traced by Cotter from Thetkegan, 2 miles W. of Myaing, for a distance of 9 miles to S. S. E. The structure is said to be similar to that of the Gwegyo anticline. Several gas pools and oil seepages were found in the central portions of the area (P. 138).

SHINMADAUNG (21° 34′ 30″ : 95° 9′). According to Hallowes, three Burmese wells sunk near the volcanic hills in this neighbourhood are said to have yielded oil. A deep boring put down by the Burma Oil Co. was not successful (P. 138).

YENANGYAT (21° 6′ : 94° 51′). The occurrence of oil seepages near Yenangyat was noticed by Oldham (1236—17, 320) in 1855; but the oil was apparently neglected by the Burmese, for Noetling (1311—27, 170) says that the construction of pit wells was not begun

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till some years later. The total length of this inlier of Pegu beds is about 39 miles, and the maximum width 3½ miles. The general direction is from N. N. W. to S. S. E., corresponding with that of a narrow range, the Tangyi hills, which for the greater part of its length lies close to the western bank of the Irrawaddy, and is steeply scarped on the side facing the river.

The geology and structure of the central and southern portions of the inlier, comprising the Yenangyat and Singu oil fields,—the latter (noted above) situated in the Myingyan district on the eastern side of the river,—have been described by Grimes (**712**), and that of the northern portion, lying to the west of SABÉ (21° 17′ : 94° 48′), by Cotter (**372—5**). The rocks form a strongly asymmetric anticlinal fold, the eastern limb of which is highly inclined or vertical and in places inverted, while the western is inclined generally at an angle of about 20 degrees. The elevation of the crest line undulates in a direction transverse to the anticlinal axis, rising to a maximum three times as the fold is traced from S. to N.; these crest maxima coinciding with the three productive oil fields of Singu, Yenangyat, and Sabé.

The effect of the asymmetry of the fold on the position of the subterranean oil pools with regard to the crest line, and its bearing upon the correct location of well sites, has been discussed in a special paper by Pascoe (**1369—2**), who has shown that in consequence of the hade westwards of the "crest locus" the productive oil sands do not lie vertically below each other, as at Yenangyaung, but that the deeper oil pools will be found at a progressively greater distance to the west of the visible crest. No oil has been obtained from the eastern side of the crest line, except in small quantities from shallow hand dug wells.

The oil from Yenangyat and Singu contains a higher proportion of the lighter hydrocarbons than that from Yenangyaung. Primary stills for the elimination of the more dangerous constituents have been erected at Singu, and are connected with the Yenangyat field by a pipe line (**P.** 101).

The production from the Yenangyat oil field has never reached very large proportions, and though the initial yield from some of the wells has been considerable,—as much as 30,000 gallons in 24 hours in one case,—a rapid decline usually sets in, and within a few months pumping has to be resorted to. Beginning with 118,409 gallons in 1893, the production from drilled wells reached a maximum of 22,631,722 gallons in 1903. Since that year it has greatly fallen off, the average annual production for the five years 1909 to 1913

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being 5,183,586 gallons; while in 1915 the output amounted to 4,099,345 gallons.

Since the year 1908, when the laying of a pipe line 275 miles in length from Yenangyaung to Rangoon was completed by the Burma Oil Co., all the producing fields belonging to this Company are connected directly with their refineries in Rangoon.

Prome.—According to Stuart (**1723**—5), the occurrences of petroleum in this district are confined to the Kama clays, or uppermost member of the Pegu series. Oil seepages have been reported to occur at the following localities, at each of which test wells have been drilled by the Burma Oil Co. without result (**P.** 176):—

NAMAYAN (18° 45′: 95° 16′). Oil and gas vents occur on the line of a large fault. There is no anticlinal structure.

PADAUNG or KAYINZU (18° 44′: 95° 14′). Oil issues from the base of the Kama clays.

TAUNGBOGYI (18° 46′: 95° 4′ 30″). Oil was reported by Theobald (**1763**—15; —16, 349) to issue from nummulitic strata exposed on the Mahu Kyaung, 3 miles above the village. A well sunk in the bed of the stream by a Chinese trader is said to have yielded 2 gallons of oil a day, but the supply soon ceased.

ZIAING or THINGAN (18° 52′ 30″: 95° 10′). Oil occuts on the same horizon as at Kayinzu, close to a fault.

Indications of oil have also been reported to occur at a spot about 23 miles to the E. of Prome, between PAUKKAUNG (18° 54′: 95° 33′) and the range of hills immediately to the west (**P.** 178).

Shwebo.—KYUNHLÁ (23° 23′: 95° 22′). Wells sunk in this neighbourhood are said to have yielded a good quality of oil, but they have been abandoned on account of the unhealthiness of the place (**P.** 147).

Thayetmyo.—AUKMANEIN (19° 14′: 94° 59′). Oil is reported by Stuart (**1723**—6) to issue from Kama clays near this place during the wet months. All the beds dip eastwards, and the structure is very unfavourable for the accumulation of oil in quantity (**P.** 172).

BAMBYIN (19° 25′: 95° 4′ 30″). Several oil seepages were observed by Theobald (**1763**—15, 121; —16, 348) in the bed of a stream about a mile above the village. The oil issues from Kama clays, according to Stuart (**1723**—6, 273), forming an asymmetric anticline with steep dips on the north. Small quantities of oil have been obtained from shallow wells, and four test wells drilled

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by the Burma Oil Co., met with oil and gas, but not in paying quantities (**P.** 171).

KAMA (19° 1′ 30″ : 95° 9′). Oil has been reported to occur to the S. of the town, and indications of an escape of natural gas have been observed in the neighbourhood (**P.** 176).

LINGA (19° 41′ : 94° 59′) and MONAT KON (19° 47′ 30″ : 95° 11′ 30″). Seepages of oil are reported to occur at these places (**P.** 169).

MINDEGYI-KYAWDO anticline (19° 45′ : 95° 0′). This anticline has been mapped by Sethu Rama Rau (*see* Hayden, **793**—26, 78). The fold is symmetrical, with shallow dips ranging from 10 to 25 degrees. Oil seepages occur in places, and the prospects of obtaining oil are regarded as decidedly promising (**P.** 169).

PADAUKPIN (19° 22′ : 95° 8′). The rocks here exhibit the same character and structure as at Bambyin. The occurrence of oil has been recorded by Theobald (**1763**—10, 73 ; —16, 347) and Romanis (**1511**—9). The latter observer says that seven wells had been dug, one of which yielded about one barrel of oil monthly. The locality has also been described by Robertson (**1499**, 232), who says that three oil sands occur within 500 feet from the surface, but that oil is found only in limited quantities. Test wells drilled by the Burma Oil Co. met with gas and oil, but the prospects were not encouraging (**P.** 170).

PYALO (19° 9′ : 95° 14′). A group of mud volcanoes is situated to the S. of the village, on a N. W.—S. E. anticline. A shaft sunk to a depth of 95 cubits by Messrs. Jamal Bros., met with no oil (**P.** 173).

TAGAING-SINMADAUNG anticline (19° 49′ 30″ : 95° 2′). According to Sethu Rama Rau (*see* Hayden, **793**—26, 78), this anticline is asymmetric on the north and symmetrical on the south, but the dips are very high, and the prospects of obtaining oil are regarded as poor.

THABYEMYAUNG (THETKEMYAUNG, 19° 47′ : 94° 48′). A N. W.—S. E. anticline, the crest of which is marked by hot springs and mud volcanoes, is recorded by Dalton (**409**, 611). The rocks are probably of Oligocene age (**P.** 169).

YENANMAN (19° 46′ 30″ : 94° 50′ 30″). Small 'shows' of oil have been met with in test wells drilled by the Burma Oil Co. Mud volcanoes occur at YEGUBWET, 4 miles, to the W. of the village (**P.** 169).

Toungoo.—SHANLÉBYIN (19° 29′ : 96° 32′). Bleeck has reported the occurrence of an oil seepage close to the village (**P.** 178). The locality lies far to the east of the main Burmese oil belt.

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Kohat.—Panoba (33° 37′ : 71° 58′). The existence of petroleum in the neighbourhood of Kohat is mentioned by Burnes (**235**—7) and Wood (**1958**—2, 144) but the precise localities are not stated. Lyman (**1112**—1, 34) described the oil at Panoba as issuing from fissures in an overfolded anticline of nummulitic limestone; but Griesbach (**708**—21, 101) says that there is no trace of anticlinal structure here, but that the oil issues from joints in the rocks adjoining a fault. The maximum yield was about 2 quarts daily (**B.** 130).

According to Pascoe (*see* Hayden, **793**—31, 23), the seepages occur on the pitch of a well developed anticline, the crest of which has been deeply eroded.

Shirani.—Moghal Kot (31° 27′ 30″ : 70° 8′ 30″). Vigne (**1846**—3, 61), writing in 1840, states that a mineral oil was brought to him from a locality near the Takht-i-Suleiman, W. of Draband which is probably to be identified with Moghal Kot. An account of the properties of the oil, contributed by Solly, is given in a foot note. It had a sp. gr. of 0·8491, was fluid at 60° F., and ignited at a temperature between 200° and 300° F. The presence of solid bituminous matter dissolved in the oil was noted, and clear liquid-naphtha of sp. gr. 0·8168 was obtained from the crude oil by distillation.

In the year 1889, samples of oil from Moghal Kot were sent to Calcutta, and were examined by Dr. Warden, who pronounced them to be of excellent quality. A brief report on the locality was made in 1891 by Oldham (**1324**—35), and in the following year further details were given by La Touche (**1034**—19). The oil oozes at several spots from a band of sandstones exposed in a narrow gorge, about a mile to the W. of the village. The rocks dip steadily eastwards, forming the greatly eroded eastern limb of a very large anticlinal fold, the crest of which forms the Takht-i-Suleiman range. Along the line where the petroleum springs issue, there appears to be a slight twist in the strike of the rocks, which has probably determined the escape of the oil at this particular spot. No oil was observed elsewhere in the sandstones, which are well exposed to the north and south of Moghal Kot. The prospects of obtaining oil in paying quantities are therefore not promising.

Analyses of samples of the oil, carried out by Holland (**859**—1; —7) in the Geological Survey laboratory, show that the crude oil has a sp. gr. of about 0·820, and contains about 80 per cent. of 'water white' illuminating oil with a flashing point above 73° F.

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and sp. gr. 0·810. The oil also contained about 8 per cent. of solid paraffin.

PUNJAB.

Attock.—KHAUR (33° 15′ : 72° 31′). An output of 250,000 gallons of oil, from wells drilled by the Attock Oil Co., is reported for the year 1915. The oil occurs at a horizon considerably higher than that at which it has been found in Burma, and the structure is said to be highly favourable to the accumulation of petroleum over an extensive area (*see* Hayden, *Rec. Geol. Survey, India*, Vol. XLVII, 23, 162).

In the year 1870 a report on the occurrences of petroleum in the Punjab was drawn up by Lyman (**1112**—1), in connection with a project, soon afterwards brought into operation, for lighting the town of Rawalpindi with gas derived from the oil. The report deals only with the indications of oil visible at the surface, and no exploratory work was undertaken. The oil usually occurs at or about the horizon of the upper nummulitic limestone, in strata that have been subjected to violent folding and dislocation by faults. The presence of the latter and the effects of denudation, which has in most cases removed the crests of the anticlines, account for the existence of numerous seepages, but are decidedly unfavourable to the retention of oil in any considerable quantity below ground. The area at Khaur, noted above, is the only one yet discovered in which these adverse conditions seem to be absent.

Seepages of oil are reported by Lyman and others to occur at the following localities. Some of them have recently been visited and reported on by Pascoe (*see* Hayden, **793**—31, 22). (The page numbers refer to Lyman's report) :—

BORARI (33° 34′ 30″ : 72° 36′ 30″), p. 29. An accumulation of about 6 cub. yds. of asphalt and earth saturated with bitumen was seen by Lyman, with an insignificant amount of oil (**B.** 130).

CHHARAT (33° 35′ : 72° 37′), p. 26. Several oil seepages occur, lying, according to Pascoe, on the crest of an E.—W. anticlinal fold, which is sharply bent and deeply eroded. The prospects of obtaining oil in commercial quantity are very poor (**B.** 130).

CHAK DALLA (33° 39′ : 72° 26′), p. 31. Two small accumulations of asphalt were noted by Lyman. Pascoe describes the rocks as consisting of hard massive nummulitic limestone, folded into a narrow anticline and so deeply eroded that very little of the crest remains. The prospects of obtaining oil are not good (**B.** 130).

GUNDA or SUDKAL (33° 35′ : 72° 41′), near Fatehjang, p. 20. Three oil seepages occur here, issuing, according to Pascoe, from nummulitic beds folded into narrow and deeply denuded

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anticlines, separated by equally narrow synclines. The geology of the locality has also been described by Wynne (**1975**—9), and the prospects of obtaining oil in quantity discussed. Several wells and borings had been put down, and yielded on the average about 2,000 gallons of oil annually, which was used in Rawalpindi for gas making. In recent years the combined output of these springs, and of those at Jaba in Mianwali, has varied between 800 and 1,700 gallons annually (**B.** 131).

JAFAR (33° 33′ : 72° 36′). A boring put down here in 1869 is said to have met with a slight show of oil. Pascoe remarks that the structure is unfavourable, and that it is very doubtful whether oil was found, as reported (**B.** 130).

LANDIGAR (33° 30′ : 72° 55′), p. 18. A mass of asphalt, about 1,000 cub. yds. in extent, was observed by Lyman, with a small quantity of oil. The rocks are nummulitic sandstones with a high dip (**B.** 131).

SADIALI (SADHEWALI, 32° 36′ 30″ : 71° 58′), p. 41. A little oil issues from sandstones overlying the nummulitic limestone of the Salt Range plateau (**B.** 128).

Mianwali.—BASTI ALGAD (32° 33′ 30″ : 71° 22′), p. 36. Deposits of asphalt extend at intervals for about a quarter of a mile along the E. bank of a ravine, amounting in all to about 550 tons. Fleming (**591**—5, 265) says that petroleum exudes in considerable quantities from the rocks, and was collected by passing bunches of grass over the surface of the water on which it floats. According to Wynne (**1975**—28, 269), the rocks exposed here probably belong to the Ceratite (Triassic) group (**B.** 129).

JABA (32° 52′ : 71° 44′), pp. 38, 41. Two groups of oil springs, known as Chhota and Bara Katta, are situated 1½ and 1¾ mile respectively to the S. of Jaba. The locality has been described by Fleming (**591**—3, 689; —5, 347), Wynne (**1975**—18, 264), and Daru (**421**—1). The oil exudes from crevices in a band of nummulitic limestone, which is bent into a flat anticlinal fold. The yield was about 50 gallons a month. A boring put down near the springs met with a powerful flow of fresh water at 117 feet, which drained the natural springs dry, but no oil was found (**B.** 128).

Rawalpindi.—BASALA (33° 30′ 30″ : 72° 57′), p. 17. Oil rises from a band of shales exposed in the bed of the Sil R. The yield is exceedingly small (**B.** 131).

CHIRPAR HILL (33° 30′ : 73° 0′), p. 16. Oil oozes in extremely small quantity from the roof of a cave on the south side of the hill (**B.** 131).

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RATTA HOTAR (33° 45′ : 73° 10′ 30″), p. 14. This locality is alluded to by Middlemiss (**1219**—17, 287) as SHAH-KI-NURPUR. The water of a spring is covered with a film of oil, which is skimmed off and sold as a medicine for sores. The rocks, according to Pascoe, are massive nummulitic limestones and Upper nummulitic shales, faulted against the red shales, etc., of the Murree series, and severely folded. The prospects of obtaining oil are said to be unpromising (**B.** 132).

SYDPUR (33° 45′ : 73° 8′). A seepage of oil similar in mode of occurrence to that at Ratta Hotar is recorded by Middlemiss (**1219**—71, 287).

Shahpur.—Seepages of oil, in exceedingly small quantities, are recorded by Lyman (p. 41) at the following localities :—

CHINNUR, near MARDOWAL (32° 36′ 30″ : 72° 13′ 30″).
DUMA, near KHABAKI (32° 37′ : 72° 17′ 30″).
HANGUSH, near DHADO (? DHUDDER, 32° 37′ 30″ : 72° 15′).

In each case the oil issues from sandstones overlying the nummulitic limestone of the Salt Range plateau. According to Pascoe (*see* Hayden, *Records, G. S. I.*, Vol. XLVII, 23), the Mardowal and Khabaki seepages occur on an open anticline of favourable shape and with gentle dips, but the rocks are hard and impervious (**B.** 127).

Wynne (**1975**—18, 236) mentions a seepage of a similar kind at SULGI, near AMB (32° 30′ 30″ : 71° 59′), on the southern side of the Salt Range. The oil issues from Tertiary sandstones overlying a detached mass of nummulitic limestone.

A general account of the topography and geology of the Punjab oil region was published by Lyman (**1112**—2) after his return to America.

PHOSPHATES—IRON.

ASSAM.

Sibsagar.—Specimens of 'blue earth' forwarded by Jenkins (**938**—3) from the banks of the DIKHU R. above NAZIRA (26° 55′ : 94° 48′) were found on examination by McClelland to owe their colouration to the presence of **vivianite**,—phosphate of iron. The colouring matter was insoluble in water and oil (**B.** 420).

BENGAL.

24-Parganas.—Vredenburg (**1854**—13) has recorded an occurrence of **vivianite**, met with in digging a tank at JAMALPUR (22° 38′ 30″ : 88° 45′). The mineral was found encrusting and apparently partly

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replacing logs of wood imbedded in stiff pale blue clay, at a depth of about 30 ft. from the surface.

BIHAR AND ORISSA.

Gaya.—Large masses of **triplite**,—phosphate and fluoride of iron and manganese,—are mentioned by Holland (**859**—37, 51) as occurring in a mica mine situated 2 miles to the S. E. of SINGAR (24° 34′ 30″ : 85° 33′ 30″). An output of 10 tons of the mineral during the year 1914 has been recorded.

NEPAL.

Medlicott (**1197**—39, 100) mentions the occurrence in the Khatmandu valley of a blue grey clay, through which specks of **vivianite** are freely disseminated. The clay was extensively used all over the valley as a manure (**B.** 420).

LIME.

BIHAR AND ORISSA.

Hazaribagh.—Holland (**859**—13, 135) in describing the mica-peridotite dykes of the Giridih and Raniganj coal fields calls attention to the high proportion of **apatite** present in these rocks as an original constituent, amounting in some cases to over 11 per cent. He remarks that the products of decomposition of the rock must contribute sensibly to the fertility of the neighbouring soil; but that the quantity is not sufficient to justify raising the mineral for economic purposes.

Apatite occurs abundantly in the mica-bearing pegmatites of this district. Holland (**859**—37, 50) records that, as an experiment 100 lb. of the mineral were collected from the waste heaps at the Lakamandwa mine near KODARMA (24° 28′: 85° 39′) by a number of boys in seven working hours. Much larger quantities might easily be obtained if the work were properly organised. The apatite contained 76 per cent. of phosphate of lime.

Singhbhum.—Specimens of magnetite rock from MOOSALBALI (? MOSALBONI, 22° 31′ 30″ : 86° 31′) and PATHORGORA (? PATHOLGORA, 22° 32′ 30″ : 86° 30′ 30″), containing patches of **apatite** up to half an inch in diameter and occasionally larger, have been described by Fermor (**577**—20). It is suggested that the rock, if it occurs in any quantity, might be of considerable value in the manufacture of basic steel.

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BOMBAY.

Rewa Kantha (Narukot).—Fermor (**577**—32, 648) has described a series of manganiferous rocks occurring at JOTHVAD (22° 23′ : 73° 47′), in several of which **apatite** is so plentiful as to constitute almost a quarter or a third of the rock.

MADRAS.

Nellore.—**Apatite** forms one of the prominent accessory minerals of the mica-bearing pegmatites, but is thrown away with the waste from the mica mines (**862**, 283).

Vizagapatam.—**Apatite** is a universal constituent of the rocks of the kodurite series, according to Fermor (**577**—32, 251), and may often be extracted in great abundance from the lithomarge resulting from the decomposition of the felspar in these rocks. It occurs in especial abundance at the manganese mines of GARBHAM (18° 22′ : 83° 31′), RAMABHADRAPURAM (18° 30′ : 83° 20′ 30″), and DEVADA (18° 15′ : 83° 38′).

PONDICHERRY.

In the course of a survey of the Cretaceous formations of Pondicherry, Warth (**1892**—21, 17) observed that at a certain horizon, about the middle of the series, many of the organic remains have been converted into nodules of rich black phosphate of lime. The stratum also contains numerous phosphatic concretions of a light brown colour. The bed is exposed on a low ridge to the E. of VALUDAYUR (11° 58′ 30″ : 79° 46′). Warth estimated that the bed, within a depth of 200 ft., contains nodules to the amount of 8 million tons; but the distribution of the nodules is irregular, varying between 27 and 47 lb. per 100 cub. ft. in excavations, and 70 lb. per 100 cub. ft. in shallow workings. The nodules contain from 56 to 59 per cent. of phosphate of lime, with about 16 per cent. of carbonate. Attempts made to work the deposits, mainly for export to Ceylon, have hitherto not proved successful (**862**, 283).

PUNJAB.

Jhelum.—In 1887 Warth (**1892**—13) published an analysis of phosphatic nodules discovered by him in the shales overlying the coal seam at DANDOT COLLIERY (32° 39′ 30″ : 73° 1′) and the neighbourhood. The nodules contain 30 per cent. of phosphorus pentoxide. The quantity was not considered sufficient for practical utilisation. The discovery has also been noticed by Wynne (**1975**—37).

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RAJPUTANA.

Dungarpur.—Hayden (**793**—26, 86) remarks that the **apatite** schists, reported by Daru as occurring in this State, may perhaps be put to some use, but the quantity available is unknown, as the rocks are largely obscured by soil.

UNITED PROVINCES.

Dehra Dun.—The discovery of a phosphatic deposit on the Midlands estate at MUSSOORIE (30° 27′ : 78° 8′) was announced in 1884 by Warth (**1892**—12) and King (**987**—31, 198). Nodules of phosphate of lime and layers of a phosphatic rock occur in a band of shale at the base of chert beds immediately overlying the Mussoorie limestone. The mineral was analysed by Mallet (**1159**—45) in the following year. The nodules were found to contain P_2O_5=34·70 per cent., equivalent to 75·75 per cent. tricalcic phosphate. The rock contained P_2O_5=30·16 per cent., equivalent to 65·84 per cent. of tricalcic phosphate. Exposures of the deposit were found at three places in a length of a mile.

PITCHBLENDE *see under* **RARE MINERALS.**

PLATINUM.

ASSAM.

Lakhimpur.—Platinum was found by Dalton and Hannay (**408**, 91) accompanying gold in the sands of the Noa Dihing R. (27° 33′ : 96° 0′). A sample of the concentrates collected by them was examined in 1882 by Mallet (**1159**—30), who describes the platinum as occurring in minute flattened grains, with a not inconsiderable proportion of scales of a lead grey mineral, which he identified as **iridosmine.** The largest scale of platinum weighed 0·095 gr., and that of iridosmine 0·06 gr. Both minerals occurred in very small proportions as compared with the gold. The platinum in this river, as well as that found in the rivers of Upper Burma, is probably derived from the crystalline rocks of the Patkoi range (**B.** 168).

BIHAR AND ORISSA.

Manbhum.—Mallet (**1159**—30, 55) detected minute grains of platinum in a sample of stream gold from the GURAM R. near DHADKA (22° 48′ : 86° 34′). The largest scale weighed 0·005 gr. Similar scales were found in gold concentrates from other rivers in the same region, and it seems probable that platinum is widely diffused in

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the southern part of Chota Nagpur. Grains of larger size, if they occur, are probably rejected by the native gold washers.

BURMA.

Chindwin (Lower).—In 1831 Prinsep (**1436**—6) published the analysis of an alloy obtained by melting together metallic grains found with gold dust in the Chindwin R. The alloy contained 25 per cent. of platinum, and 40 per cent. of **iridosmine**, the remainder consisting of gold, iron, arsenic and lead. In further communications on this subject (**1436**—10, 16; —13), Prinsep states that the platinum is said to come from streams flowing westwards into the Chindwin R. near KANI (22° 27′: 94° 53′), and that the ore contains 20 per cent. of platinum, with about twice that quantity of **iridosmine** (**B.** 168).

Chindwin (Upper).—Hannay (**760**—6, 12) states that platinum occurs in appreciable quantities in the auriferous sands of the Hukawng valley. It was detected by Bion (**127**, 246) at almost every locality where gold was found, but in very small amounts.

Katha (Wuntho).—A specimen of gold ore from the MEZA R. (24° 8′: 96° 4′) was found by Romanis (**1511**—10; —12) to contain 2·53 per cent. of platinum and 7·04 per cent. of **iridosmine.**

Myitkyina.—Small quantities of platinum are obtained yearly by the Burma Gold Dredging Co. from the gravels of the Irrawaddy above Myitkyina. During the years 1911 to 1915, the returns furnished by the Company include a total of 206·39 oz. of the metal.

Tavoy.—Minute quantities of platinum were detected by Oldham (**1326**—1, 38) in stream tin concentrates brought from the neighbourhood of the HENZAI BASIN (HEINZÉ, 14° 45′: 98° 0′) by O'Riley (**B.** 168).

MYSORE.

Kolar.—Rice (**1477**, Vol. I, 18) mentions the occurrence of platinum in small quantities in the gold washings of the Kolar district.

PORPHYRY *see under* **BUILDING MATERIALS.**

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POTASH SALTS.

PUNJAB.

Jhelum.—While engaged in making a collection of the mineral products of the Salt Range for the Vienna Exhibition of 1873, Dr. Warth (**1892**—8, 408) noticed the comparative hardness of a band of *kallar*, or impure salt, met with in the Mayo salt mines at KHEWRA (32° 39′ 30″ : 72° 4′), and he found, on making a preliminary analysis, that the material consisted of a mixture of potash salts with **kieserite** ($MgSO_4$, H_2O) and common salt (*see also* Wynne, **1975**—12, 60). Specimens examined by Tschermak (**1808**—7) were found to be composed of **sylvite** (KCl) and **kieserite.** A colourless mineral associated with these, afterwards examined by Mallet (**1159**—58), proved to be **langbeinite** (K_2SO_4, $2MgSO_4$). The quantity of material obtained did not amount to more than half a ton, since the deposit was found to die out rapidly in a lateral direction. On analysis by Tween (quoted by Wynne, **1975**—18, 80, and Mallet, **1159**—50, 33), the mixture yielded :—KCl=61·43 : NaCl=29·32 : $MgSO_4$=7·78 : H_2O=2·10 per cent.

A search for further deposits was made by Christie (**311**—4) in 1913, when potash salts were found at 21 places in the Mayo mines. These occurrences indicate the existence of three seams, each of which appears to thin out when followed along the rise of the strata. The amount of potash contained in the visible portion of the uppermost seam, with an average thickness of about 6 ft., was provisionally estimated at 3,000 tons. The other seams probably contain only a few hundred tons. The percentage of potash contained in average samples ranged from 7·7 to 14·4. Suggestions for the treatment of the mineral with the object of extracting the potash salts are included in the report.

A bed of similar material was also found in a salt mine in the Nilawan ravine near NURPUR (32° 40′ : 72° 39′), several miles to the west of Khewra. The bed when bored through was found to be about 6 ft. thick, but its lateral extent was not ascertained. Samples from the boring contained 13·6 per cent. of potash.

POTSTONE *see* **STEATITE.**

POTTERY CLAY *see* **KAOLIN.**

PYRITES *see* **ALUM, COPPER,** *and* **SULPHUR.**

PYRRHOTITE *see* **SULPHUR.**

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QUARTZ *see* **GEM-STONES—ROCK CRYSTAL** *and* **ROSE QUARTZ.**

QUARTZITE *see under* **BUILDING MATERIALS.**

RADIOACTIVE MINERALS *see* **RARE MINERALS—PITCHBLENDE** *and* **SAMARSKITE.**

RARE MINERALS—CERIUM.

MADRAS.

Kurnool.—A fawn-coloured mineral obtained by Newbold (**1294**—49, 390) in the old lead mines at BASWAPUR (BASAVAPURAM, 15° 24′ 30″ : 78° 41′ 30″), was described by Piddington (**1405**—22) as a triple carbonate of iron, lime, and cerium, mixed with galena. Mallet (**1159**—50, 153) has shown that the mineral is smithsonite, containing zinc and not cerium (**B.** 436).

Salem.—Among the minerals collected by Leschenault de la Tour in S. India, a brown or black substance analysed by Laugier (**1038**—1, 194) was found to contain 36·5 per cent. of oxide of cerium, and was identified by Damour (**413**—2) with **tscheffkinite.** The position of the locality where the specimens were obtained has been discussed by Mallet (**1159**—53), who thinks that it was situated on or near KANJAMALAI HILL (11° 37′ : 78° 7′).

See also **SAMARSKITE** *below.*

COLUMBITE *and* **TANTALITE.**

Columbite and tantalite,—the niobate and tantalate of iron and manganese,—are occasionally met with in the mica-bearing pegmatites of Bihar and Orissa and of S. India. Instances of their occurrence have been recorded (*see* Fermor, **577**—32, 203) at the following places :—

BIHAR AND ORISSA.

Gaya.—SINGAR (24° 34′ 30″ : 85° 33′ 30″). These minerals are said to occur in a mica mine at this locality (**862,** 284).

Hazaribagh.—KODARMA (24° 28′ : 85° 39′). Specimens of **columbite** from the Government Forest near Kodarma were sent to the Geological Survey Office by Mr. Gow Smith in 1897 (Oldham, **1324**—54, 129). The specific gravity of the specimens was 6·19.

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Monghyr.—PANANOA HILL, 4 miles S. of JHA-JHA (24° 47′ 30″ : 86° 26′). An occurrence of **columbite** and **tantalite**, discovered by Mr. H. H. French, was examined by Holland in 1894 (*see* Griesbach, **708**—27, 10). The mineral was found in lumps imbedded in the quartz of a very coarse pegmatite dyke, intrusive in mica schist crowded with tourmaline crystals. Specimens subsequently received in the Geological Survey Office have specific gravities of 6·75 and 6·92, and contain 37 and 52 per cent. of tantalic acid (Ta_2O_5) respectively (**862**, 284).

BURMA.

Tavoy.—Bleeck (**154**—4, 68), in describing the wolframite lodes of this district, observes that **columbite**, in black orthorhombic crystals, was found in all the lodes.

MADRAS.

Madura.—Balfour (**69**—4, iv) mentions **ferro-tantalite** among the specimens of rocks and minerals collected by the Revd. C. F. Muzzy in the Madura district. The locality is given by Nelson (**1286**, 16) as near PALANI (? PALNI, 10° 27′ : 77° 34′).

Nellore.—CHAGANUM (14° 13′ : 79° 44′ 30″). Specimens of a black mineral from mica pegmatites, collected at this locality by Walker, were found on examination at the Geological Survey laboratory. (*see* Griesbach, **708**—31, 9) to be **columbite**, with a specific gravity of 5·748.

Trichinopoly.—SEMMALAI HILLS, near VAIYAMPATTI (10° 33′ : 78° 23′). A mineral discovered by Mr. C. Middleton when excavating for mica in these hills proved to be **tantalite** containing 66 per cent. of tantalic acid (Ta_2O_5). A specimen received in the Geological Survey Office was found to be nearer **columbite** than tantalite (**862**, 285).

MYSORE.

Bangalore.—MASTI (12° 52′ : 78° 30″). **Columbite** has been found by Jayaram (**937**—2, 182) in a vein of pegmatite traversing hornblendic granitoid gneiss, about 3½ furlongs to the N. of the town, and 100 yards from the tank *bund*. The mineral occurs in considerable quantity. An output of 112 lb. was reported in 1913 (**862**, 284).

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GADOLINITE.

BOMBAY.

Palanpur.—A discovery by Baidyanath Saha of **gadolinite,**—silicate of **beryllium, yttrium,** and **iron,**—at HOSAINPURA (24° 15′ : 72° 36′), has been recorded by Holland (**859**—43). The mineral is associated with cassiterite in tourmaline pegmatite.

PITCHBLENDE.

BIHAR AND ORISSA.

Gaya.—The occurrence of **pitchblende,** associated with **uranium ochre** and triplite, in a mica mine near SINGAR (24° 34′ 30″ : 85° 33′ 30″) was recorded in 1902 by Holland (**859**—37, 51). According to Burton (*see* Hayden, **793**—31, 24), the mineral occurs as nodules in a band of mica pegmatite about 40 yards in width. The largest nodule found weighed 36 lb. About 6 cwt. of pitchblende had been found by the year 1913. The returns for 1915 include 16 lb. obtained at this locality.

SAMARSKITE.

MADRAS.

Nellore.—The existence of **samarskite,**—a complex niobate and tantalate of **uranium, yttrium, iron,** etc.,—in one of the Nellore mica mines appears to have been first brought to notice by P. N. Bose about the year 1907, but no details of the occurrence or locality were furnished. In 1910 specimens were forwarded to Calcutta by R. R. Simpson, who obtained them from the Sankara mica mine near GRIDALUR (14° 16′ 30″ : 79° 50′). These included a fragment 13 lb. in weight, with a specific gravity of 5·74 (*see* Tipper, **1787**—7). In a later paper (**1787**—11) Tipper gives further details of the occurrence. The samarskite is found in irregular angular masses, ranging from minute fragments up to 200 lb. in weight, in pinkish brown felspar forming one of the constituents of a garnetiferous pegmatite. The mineral is strongly radioactive.

Two other minerals containing uranium were found in the same mine.

An output of 43 cwt. of samarskite is reported for the year 1914, as against 3 cwt. in 1913.

TITANIUM.

BIHAR AND ORISSA.

Manbhum.—Ball (**71**—46, 107) mentions the occurrence of massive **ilmenite** at the foot of the hills to the W. N. W. of MANBAZAAR

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(23° 3′ 30″ : 86° 43′). In the neighbourhood of SUPUR (23° 1′ : 86° 55′ 30″) it occurs in large masses weathered out from quartz veins, and in lamellar plates or seams *in situ* (**B.** 323).

Well developed crystals of **rutile**, sometimes half an inch in thickness, were found by Warth (**1892**—23, 51) on the surface of the ground near the outcrop of a kyanite vein exposed in the neighbourhood of SALBANNI (23° 4′ : 86° 20′).

MADRAS.

Travancore.—**Ilmenite** in small masses or isolated crystals is a common constituent of the charnockites and pyroxene granulites of Peninsular India (Holland, **859**—31, 126). It occurs in abundance in the monazite sands on the coast near CAPE COMORIN (*see* Tipper, **1787**—12, 187).

Trichinopoly.—Bose has reported the occurrence of **rutile** in the neighbourhood of KADAVUR (10° 36′ : 78° 15′)—(**862**, 285.)

PUNJAB.

Patiala.—According to Bose (**173**—21, 59), a massive form of **rutile** has been met with in the course of mica exploration near GHATASHER (27° 58′ : 76° 5′ 30″) in the Narnaul district. The mineral appears to occur in some abundance in the Arvali series.

RAJPUTANA.

Alwar.—Hacket (**730**—4, 249) has recorded the occurrence of small quantities of **rutile** in quartz veins in the MOTIDONGRI RIDGE (27° 32′ : 76° 39′), a short distance to the S. of Alwar (**B.** 324).

Kishangarh.—An occurrence of **ilmenite**, formerly smelted as a ore of iron, near KANCHRIA (26° 32′ : 74° 56′ 30″), has been recorded by Vredenburg (**1854**—8). The mineral is found in large well shaped crystals associated with quartz and calcite in a broad vein traversing granitoid gneiss. The specific gravity is 4·60.

UNITED PROVINCES.

Mirzapur.—Mallet (**1159**—5, 22) notes that **ilmenite** sand occurs in some of the streams in south Mirzapur.

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VANADIUM.

MADRAS.

Travancore.—According to a partial analysis made by Chacko (**298**, 53), a sample of the ash from lignite occurring in the Warkalli beds contained 2 per cent. of vanadium oxide; but no trace of this element was detected in two samples of the ash analysed at the Imperial Institute (*l. c.*, pp. 81, 82).

REH *see* **SODA.**

ROCK CRYSTAL
ROSE QUARTZ. } *see under* **GEM-STONES.**

RUBELLITE *see* **GEM-STONES—TOURMALINE.**

RUBY *see under* **GEM-STONES.**

RUTILE *see* **RARE MINERALS—TITANIUM.**

SALT.

The sources from which the indigenous salt supply of India is derived may be divided into three categories:—(A) Sea water evaporated by solar heat. (B) Brine from lakes in areas of internal drainage, brine springs and wells, or obtained by the lixiviation of saline soils and evaporated by artificial means. (C) Deposits of rock salt, quarried or mined in certain districts of the North-West Frontier Province and the Punjab.

General accounts of the salt resources of India have been given by Warth (**1892**—8), Ball (**71**—55), and Ashton (**44**).

During the quinquennial period 1909 to 1913, the larger proportion, amounting to about 70 per cent., of the indigenous output was obtained from sea water,—Aden and the Presidencies of Bombay and Madras being the chief producers. Rock salt accounted for about 10 per cent. of the total. The bulk of the remainder was derived from lake and subsoil brines in the Rajputana desert. The average annual production for the whole of India, including Aden and Burma, during this period, was 1,412,274 tons. The average amount imported annually from foreign countries was 460,000 tons. In 1915 the total production amounted to 1,745,521 tons, and the quantity imported, excluding that from Aden, to 417,237 tons. The cessation of supplies from Germany, with the exception of 1,020 tons

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from prize cargoes, and from Asiatic Turkey, was largely balanced by enhanced imports from Egypt, Spain, and the United Kingdom.

ADEN.

The average annual production of salt from sea water in Aden and its dependencies, during the quinquennial period 1909 to 1913, was 110,373 tons. Of this amount, 92,295 tons, or 16·7 per cent. of the total, was exported to India annually. In 1915 the amount produced was 352,232 tons, of which 102,286 tons were exported to India.

AFGHANISTAN.

Hutton (**900**—8, 601) states that salt was obtained in KUSHK-I-NAKHUD (31° 43′ : 65° 0′) by washing the soil and boiling down the brine. A superior article was brought from GURMSAEL (GARMSIR, 30° 30′ : 63° 10′), where the water of a stream flowing from the hills left cakes of salt resembling ice on the surface of a swamp on evaporation. The city of Kandahar was supplied from these sources.

Medlicott (**1197**—57) notes the receipt of specimens of rock salt from PARE ANGURI in the Chakmani country, 20 miles to the W. of KURRAM FORT (33° 49′ : 70° 8′). No use appears to have been made of this salt, for the greater part of Afghanistan was supplied from the Kohat district, N.-W. Frontier Province (**B.** 481).

ASSAM.

Cachar.—The manufacture of salt from brine wells is mentioned in the Statistical Account of Assam (**896**—3, Vol. II, 370). The salt is said to be much inferior in quality to that imported from Bengal. In 1875 the industry was practically extinct.

Lakhimpur.—Salt was formerly manufactured, according to Robinson (**1503**—1, 33), from brine springs situated at BORHAT (27° 10′ : 95° 25′) and SADIYA (27° 50′ : 95° 43′). The production at the latter place in 1809 is said to have been about 3,700 tons. The brine was boiled down in bamboos, pared so thin that the percolation of moisture from within prevented their burning (**B.** 491).

Naga Hills.—Owen (**1352**) has described a similar method of salt manufacture practised by the Dwaria and Namsangia tribes. The brine is said to have been obtained from 85 springs, usually rising in the beds of rapids in the streams.

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Nowgong.—Hunter (**896**—3, Vol. I, 176) says that a salt mine is known to exist at JANGTHANG, in the Mikir Hills, but the statement requires confirmation (**B.** 491).

BALUCHISTAN.

Quetta-Pishin.—Hutton (**900**—8, 601) mentions the manufacture of salt in the Pishin valley from brine obtained by the lixiviation of saline soil (**B.** 481).

BENGAL.

Salt was formerly manufactured in considerable quantities in the districts lying on either side of the Hooghly below Calcutta, but the industry is now practically extinct. Hamilton (**747**) has described the method practised in the **Midnapore** district about TAMLUK (22° 18′: 87° 58′ 30″), and McClelland (**1117**—24) and Ashton (**44**, 139) that in the **24-Parganas**, on the eastern side of the river. Sea water was admitted on to ground levelled for the purpose, and when impregnated with salt the earth was scraped up and lixiviated in straw filters. The brine was then boiled down, either in nests of small earthen vessels fastened together honeycomb fashion with stiff clay, or in shallow iron pans. In works of the first kind, known as *Baharbang*, evaporation was carried on only during the day; while in the second, or *Tuffal* works, green wood was used and the evaporation proceeded continuously. McClelland appends directions for the preparation of sulphate and carbonate of magnesia from the bittern or waste liquor.

BIHAR AND ORISSA.

In the saline tracts bordering the coast of Orissa, salt was manufactured in **Balasore** and **Cuttack** by a process similar to that employed in Bengal, and in **Puri** by solar heat. In the latter district salt water was led by canals from the Chilka lake into rows of shallow pits arranged in sets of four, increasing successively in depth from 18 ins. to 3 ft. The final concentration was effected in pools 6 ins. deep and 5 ft. square. The production in these districts amounted in 1875-76 to about 10,500 tons, according to the Statistical Account of Bengal (**896**—2, Vol. XVIII, 175,336; Vol. XIX, 151).

A certain quantity of salt was formerly obtained as a bye-product in the manufacture of saltpetre in the Bihar division, but no output is now recorded in the annual returns of mineral production. An analysis of the salts accompanying the saltpetre was given by Piddington (**1405**—10) in 1841, when the quantity of edible salt produced was estimated at about 10,000 tons annually.

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BOMBAY.

A large proportion of the Indian production of salt, amounting to an average of 481,879 tons annually during the quinquennial period 1909 to 1913, or 37 per cent. of the total, is manufactured in **Bombay** and **Sind** from sea water, or from subsoil brine as in **Cutch**; where, according to Wynne (**1975**—11, 89), nearly all the rocks, especially the upper Jurassic and lower Tertiary beds, are strongly impregnated with chloride of sodium and other salts. The same observer remarks (*l.c.*, p. 19) that the salt naturally formed on the floor of the Runn of Cutch does not form an important article of export, and usually has a rather bitter taste. In 1915 the quantity of salt produced in the Presidency was 524,257 tons.

In 1847 Macleod (**1138**) and Burke (**233**) called attention to the existence of extensive beds of salt in the neighbourhood of the Kori and Gangra branches of the Indus, opposite LAKHPAT (23° 50′: 68° 51′). One of the deposits is said to extend for a length of about 20 miles, by 15 miles in breadth, with an estimated thickness of 3 ft., and would contain about 1,500 million tons of salt (**B.** 481).

BURMA.

In addition to the salt manufactured from sea water in the coastal districts,—for a description of the process *see* Thurley (**1783**),— large quantities were formerly extracted from water furnished by brine springs and wells, especially in the 'dry zone,' where the water from deep wells is almost always noticeably saline. Brine springs frequently occur in crushed or distorted strata among the rocks included in the Burmese petroleum belt. Reference to their occurrence has been made by the following writers:—

Chindwin (Upper).—Hannay (**1385,** 270) states that in the Hukawng valley salt was obtained from brine springs on the Namwon-kok and Edi rivers.

Grant (**692**—2, 130) mentions the existence of brine springs and wells at several places in the valley of the Maglung or Yu R. (Kabaw valley), between YUWA (23° 54′ 30″: 94° 35′) and TAMMU (24° 13′: 94° 21′).

Katha.—Noetling (**1311**—18, 119) enumerates a number of salt springs situated on the western side of the MAINGTHON HILL tract (24° 10′: 95° 46′) in Wuntho. The springs rise from beds of volcanic ash, and are distributed along a N. N. W.—S. S. E. line, probably coinciding with that of a fault. They usually rise in the

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beds of streams, the water of which is cut off by sinking a hollowed-out tree trunk on the site of the spring.

Myingyan.—At SAGYIN (20° 57′ 30″ : 95° 28′) and other villages in the neighbourhood, salt was still being manufactured in 1909 (*see* La Touche, **1034**—39, 101) from the saline efflorescence derived from brine springs. After saturating the soil by repeated moistening with water from the springs and drying, the brine is washed out in large conical wicker baskets, and evaporated over a slow fire.

Pegu.—Theobald (**1763**—18), in a special report on the salt springs of Pegu, has enumerated 79 springs and wells, distributed along three lines roughly parallel to each other and to the eastern flanks of the Arakan Yoma, extending northwards through the districts of **Henzada, Prome,** and **Thayetmyo.** The most important spring is that of SAHDWINGYI (SANYWAGYI, 18° 2′ : 95° 9′), which has a discharge of 57 gallons per hour. The water contains 4,704 grs. of salt per gallon. In most cases there was no perceptible flow of water, the brine being obtained by baling from timbered wells (**B.** 492).

Sagaing.—Oldham (**1326**—17, 323) has described the process of manufacturing salt at YEGÁ (21° 59′ : 95° 59′) from the water of a small lake of brackish water. The mud from the bed of the lake was lixiviated in straw filters, and the brine, concentrated by evaporation in iron pans, was placed in baskets, in which the salt crystallised out.

Shan States (N.).—BAWGYÔ or MAW-HKEO (22° 35′: 97° 17′). The manufacture of salt from a brine well situated at this locality has been described by Noetling (**1311**—7) and La Touche (**1034**—32). The brine was found on analysis to contain about 25·5 per cent. of total salts, the composition of which was :—NaCl=60·48 : Na_2SO_4= 36·24 per cent., with small quantities of sulphate of lime and magnesia. It was estimated that the well is capable of producing about 160 tons of common salt and 70 tons of sulphate of soda per annum. The brine is evaporated nearly to dryness in shallow iron pans, the bulk of the sulphates crystallising as a hard scale on the bottom of the pan, and the salt is sold locally in its crude state.

Shwebo.—Considerable quantities of salt were manufactured in this district, according to the Gazetteer of Upper Burma (**1601,**

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Vol. II, 295), under Burmese rule. The centre of the industry was at HALIN (22° 26′: 95° 51′). The brine was obtained from the subsoil, or, when deficient in strength, by pouring water from wells over the fields and gathering the efflorescence, which was lixiviated and boiled down in the usual way. The production was from 125,000 to 200,000 viss (=200 to 320 tons) annually.

Strover (**1721**, 14) mentions extensive salt fields at SHIMPAGAH (? SHINMAGA, 22° 17′: 96° 1′ 30″), on the west bank of the Irrawaddy above Mandalay: but this was probably one of the places whence the salt from the interior of the district was shipped to the capital (**B.** 492).

The average annual production of salt in Burma, during the five years 1909 to 1913, amounted to 27,164 tons. In 1914 the output fell to 21,522 tons, but in 1915 it rose again to 28,521 tons.

CENTRAL INDIA AGENCY.

Gwalior.—A small output of salt from the Gwalior State is recorded annually in the returns of mineral production. It is manufactured from subsoil brine as in Bharatpur and Gurgaon. The average amount produced annually during the period 1909 to 1913 was 100 tons. In 1915 the output was 127 tons.

CENTRAL PROVINCES.

Akola.—Blanford (**148**—22, 284, 380) and Lyall (**1107**, 22) have described a salt industry formerly carried on in the valley of the Purna R. between DHYUNDA (DAHIHANDA, 20° 53′: 77° 11′) and OOMRAWUTTEE (AMRAOTI, 20° 56′: 77° 48′ 30″). Brine was obtained from wells sunk in the alluvium, from 90 to 130 feet in depth. The saliferous stratum is a bed of tenacious gravelly clay, from which, on being tapped, the salt water rises with considerable force to a height of 15 or 20 ft. from the bottom of the well. The brine was evaporated by solar heat in shallow pans lined with a concrete of river gravel and kankar. Wynne (**1975**—7, 3) says that the crystals of salt were small and rather dirty, but whiter salt was obtained in the hot season. Each well produced about 5 cwt. of salt monthly (**B.** 477).

Buldana.—A certain amount of salt is obtained as a bye-product in the manufacture of carbonate of soda from the brine of the LONAR LAKE (19° 59′: 76° 35′), noted under the heading **SODA**. According to analyses made by Christie (**314**—1, 283), an average sample of water from the lake contains chlorine in the proportion of 34·18 grams per litre.

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Chanda.—Oldham (**1326**—69, 80) has remarked that a deposit of brownish yellow sand or clayey sandstone, occurring beneath the alluvial gravels of a large portion of western Chanda, is distinctly saline. Samples of the salt obtained by lixiviating the sandy clay contained respectively :—NaCl=82·89 : $MgSO_4$=16·02 per cent. ; and NaCl=87·58 : $MgSO_4$=11·86 per cent.

HYDERABAD.

Gulbarga.—Foote (**596**—12, 253) states that a large quantity of salt was manufactured at BAICHUBAL (16° 33′ : 76° 37′ 30″) from brine obtained from wells sunk to a depth, according to Meadows Taylor (**1751**—2, 31) of 120 feet. The water of several of the streams draining the spreads of regur, or 'cotton soil,' in the neighbourhood, especially that of the DHON R., is distinctly saline. A stream which joins the river from the N. E. at TALIKOT (16° 28′ : 76° 22′) is said to deposit impure salt in parts of its bed when dry.

MADRAS.

The manufacture of salt in the Madras Presidency is now practically confined to the coastal districts, where it is derived from sea water, solar heat being employed in the evaporation. The process is described in the various District Manuals (*see* Garstin, **636**, 460 ; Maltby, **1162**, 279 ; Bayley, **90** ; de Havilland, **452**), and consists in admitting the water, already concentrated to a certain degree by evaporation in pits for about 25 days, to shallow reservoirs or pans about two-thirds of an acre in extent. The pans are prepared by repeatedly allowing a thin crust of salt to form, and thoroughly incorporating it with the soil by treading and ramming it in. Formerly a certain amount of salt was produced in the inland districts by the lixiviation of saline earth (*see* Mayer, **1193**—1 ; Nicholson, **1301**—1) ; but this industry has been suppressed by Government (**B.** 475).

The average annual production of salt in the Presidency, during the quinquennial period 1909 to 1913, was 404,280 tons. For the years 1914 and 1915 the quantities produced were respectively 298,862 and 345,714 tons.

MYSORE.

The manufacture of 'earth salt' in the Mysore State, as at present carried on, has been described by Primrose (**1431**—8, 207) and Sambasiva Iyer (**1548**—7, 253). The saline earth is lixiviated in troughs lined with lime plaster, and the brine is filtered through sand into shallow earthen pans, in which it is evaporated by solar heat. The yield is said to be about 3 lb. per square foot of heating surface,

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or about 2 tons annually for each pan. No trustworthy data of the total annual production are available.

NORTH-WEST FRONTIER PROVINCE.

Kohat.—Allusion to the existence of extensive beds of rock salt in the Kohat district was made in 1843 by Agha Abbas (**15**, 595, 597), and later by Verchère (**1839**—2, 26) and Oldham (**1326**—49); but it was not until the year 1874 that an adequate description of the deposits was published. In that year a report by Wynne and Warth (**1976**), afterwards reproduced in the Memoirs of the Geological Survey (**1975**—15; **1892**—7), was drawn up, giving a complete account of the geology of the region and of the economic development of the salt.

The rock salt occurs in beds of great thickness, measuring in one instance at least 1,000 feet, at a single distinct horizon overlaid by beds of gypsum, apparently followed in conformable sequence by nummulitic (Eocene) limestone. The presumption therefore is that the salt beds are of lower Tertiary age, but as the underlying beds have not been observed in any of the sections examined, and no fossils have been met with in direct association with the salt, their exact geological position has not yet been ascertained.

The beds of rock salt are exposed along the axes of a series of narrow, elliptical, anticlinal folds, so that the outcrop is never continuous for any great distance. The area over which salt is actually exposed is approximately estimated by Warth (**1892**—7, 324) at 3,082,996 sq. feet., which would yield, on the assumption that the average thickness is 100 ft., about 18 million tons of salt. Since, however, the salt may be reasonably expected to be accessible over a total area of 5 sq. miles, the quantity actually available must be much greater than this, probably not less than 1,250 million tons (**B.** 482).

The salt is usually of a greyish colour, differing in this respect from that of the Punjab Salt Range, which has a reddish tinge. It is of great purity, being only slightly contaminated with thin layers of clay, except in the upper portion, which is often impregnated with petroleum. A sample of clean salt from Bahadur Khel, analysed by Tween (*see* Wynne, **1975**—15, 130), contained :—Cl=59·52 : H_2SO_4=1·5 : CaO=1·06 : Na=37·47 : Insoluble matter=0·45 per cent. It contained no foreign salts.

At the time of Wynne and Warth's survey, the principal quarries were situated at the following places :—

Bahadur Khel (33° 11′ : 71°-1′). The outcrop extends over 4 miles in length, with a breadth of a quarter to half a mile. The

visible thickness of salt exposed, allowing for a northerly dip, is at least 1,000 feet. Two hills in the centre of the valley, about 200 feet in height, are entirely composed of salt.

JATTA (33° 19′ : 71° 20′ 30″). Outcrops and quarries extend over a space half a mile long and a quarter of a mile broad. The thickness of salt exposed in one of the outcrops was 100 ft. but the total thickness is probably much greater than this.

KHARAK (33° 7′ : 71° 9′ 30″). Quarries are worked over an area of a quarter to half a mile in length and a few hundred yards in width. The salt is covered by thick deposits of gypsum and debris, and dips at angles of 40 to 45 degrees. Exposures vary from 20 to 40 feet in height.

MALGHIN (33° 20′ : 71° 35′). The salt quarries are situated 4 miles to the S. of the village. The outcrop extends for 3 miles from E. to W. The space actually quarried was about half a mile long, and was greatly obscured by debris from old quarries, which rendered the working extremely difficult and dangerous.

NARI (33° 11′ 30″ : 71° 13′). The outcrops extend for 2 miles, but quarrying was confined to a space half a mile in length and several hundred yards broad. The thickness visible is about 200 ft.

In addition to these places, particulars of 25 old quarries and outcrops are given in the memoir (**1892**—7, 315—324). The most favourable of them as regards regular mining are said to be:—BURBURRA (33° 16′ 30″ : 71° 12′), ZAINO (33° 18′ : 71° 35′), NUNDRUKKI (33° 16′ : 71° 37′), KURAR (33° 14′ : 71° 23′), and SIRRAIKHWA (33° 10′ : 71° 16′).

At Bahadur Khel and Kharak the salt was extracted by pick axe and wedge in the form of slabs, called *tubbis* or *chakkis*, measuring 13 ins. across and 4 ins. in thickness, advantage being taken of the planes of stratification of the salt and the comparatively high dip,—about 45 degrees. At the other quarries gunpowder was used, and the salt obtained in irregularly shaped fragments.

The average annual production of rock salt in the Kohat district, during the five years 1909 to 1913, was 18,448 tons. The figures for 1914 and 1915 were 19,099 and 18,239 tons respectively.

PUNJAB.

Gurgaon.—The salt industry in this district, which was formerly of some importance, has been described by Gubbins (**721**) and Ashton (**44**, 128). The brine is derived from wells, from 24 to 40 ft. in depth, situated chiefly in the neighbourhood of the villages of NUH (28° 6′ : 77° 3′) and SULTANPUR (28° 1′ : 77° 11′). The salt water is evaporated by solar heat in shallow pans lined with lime

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plaster, arranged in sets of six, one of which is always kept filled with brine from the remaining five, the process taking from 12 to 20 days to complete, according to the season. Branches of various shrubs are placed in the pans, in order to facilitate the crystallisation of the salt. Ashton, writing in 1900, says that the industry was becoming extinct, the number of factories having declined from 390 in 1867 to 42. The salt is of inferior quality, containing from 81 to 87 per cent. of chloride, with a noticeable proportion of sulphate of soda (**B.** 490).

Jhelum and **Shahpur (Salt Range)**.—The name 'Salt Range' appears to have been first used by Elphinstone (**545**, 103) to denote the hilly country extending from the base of the Safed Koh to the banks of the Jhelum, including the salt hills of Kohat; but it is now restricted to the broken ground (not a range in the strict sense of the term) forming the southern scarp of the 'Potwar,' the elevated plain lying at the base of the Himalaya between the Jhelum and Indus rivers. The first account of the deposits of rock salt and their exploitation by the Sikhs was given by Burnes (**235**—4; —13, Vol. I, 50) in 1832; but it was not until after the annexation of the Punjab in 1849 that the geological relations of the deposits were studied.

In 1853-54 Fleming (**591**—5) and Theobald (**1763**—1) published reports on the geology and mineral resources of the Range, and showed that the saline series is apparently the oldest formation exposed. This position has also been assigned to them by Wynne in his exhaustive memoir (**1975**—18) on the geology of the Range.

The salt occurs in discontinuous beds or masses in a thick band of a peculiar bright red gypseous clay or 'marl,' which is overlaid, towards the eastern end of the Range, by a series of beds known by their fossils to be of Cambrian age. Certain anomalies, however, in the mode of occurrence of the red marls render it doubtful whether this is their true position in the geological sequence. Fleming (**591**—5, 240; —6, 197) was the first to draw attention to their resemblance in some respects to igneous intrusions. Verchère (**1839**—2, 22) attributed the deposition of the gypsum, as anhydrite, to hot springs, and the quasi-intrusive character of the beds to the increase of volume consequent upon the conversion of the anhydrite into gypsum. More recently the theory of the igneous origin of the marls has been elaborated by Middlemiss (**1219**—14, 26), who relies mainly upon the unstratified nature of the deposits; their apparently corrosive action upon included patches of dolomite; the absence of

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any traces of the marl in the Salt Range boulder bed, of Carboniferous age, even when in contact with the marl, though pebbles of unaltered dolomite derived from it occur in large quantities; and on the many instances observed of an apparent intrusion of the marls into formations of later date than the Cambrian. Holland also has shown (**859**—2) that bipyramidal crystals of quartz imbedded in the gypsum contain inclusions of anhydrite, indicating that the deposits were formed at a temperature of probably not less than 200° C. The question has again been discussed by Christie (**314**—4, 252), who has pointed out that the absence of stratification in the marl is merely superficial, sections in the interior of the mines showing distinct bedding; that the dolomite is of sedimentary origin; that the anomalous position of the marl is due to plasticity induced by the pressure of the overlying rocks; and that it has been shown that sulphate of lime may be deposited as anhydrite at temperatures above 25° C from solutions saturated with respect to sodium chloride and calcium sulphate. He concludes that the saline series is a sedimentary deposit, but that it has been depressed since the time of its accumulation to a depth sufficient to raise the temperature to at least 80° C.

In addition to Burnes' account, noted above, descriptions of the working of the mines under Sikh administration have been given by the following writers:—

1836. Court (**377**, 475).
1841. Jacquemont (**926**—3, Vol. III, 109).
1843. Jameson (**931**—3, 198).
1843. Agha Abbas (**15**, 574).
1848. } Fleming { (**591**—1, 518).
1849. } { (**591**—3).
1850. Bowring (**183**—1, 51).

Mines were formerly very numerous, but those described were situated at JUTANA (32° 43′ 30″: 73° 13′), KHEWRA (32° 39′ 30″: 73° 4′), MAKRACH (32° 40′: 72° 57′), and SARDI (32° 41′: 72° 47′) in **Jhelum**, and at VARCHA (32° 25′: 72° 2′) in **Shahpur**. The workings were entered by narrow, tortuous passages, opening into huge caverns, in which no precautions were taken for the prevention of falls from the roof. The production of salt was from 28,000 to 30,000 tons annually.

Under British rule the number of the mines was greatly reduced, and at the time of Wynne's survey only three were being worked, *viz.*, at Khewra, Sardi, and Varcha. In 1868 recommendations had been drawn up by Oldham (**1226**—49, 146) for improving the admi-

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nistration of the mines, and in 1872 a systematic plan of working was laid out by Warth (**1892**—1; —4; —5; —8), which has been followed to the present day. The most important are the Mayo mines at KHEWRA, where five salt beds are known, with an aggregate thickness of 275 feet, separated by beds of red marl and impure salt or *kallar*. The workings are laid out in blocks, thirty-seven in number, separated by pillars 30 ft. in width, which run continuously through the mine at right angles to the strike of the seams. The seams are worked from above downwards, the floor of each block being blasted away in steps. The chambers are entered from two levels furnished with tramways, which converge at a single main exit.

At SARDI the bed of salt worked was 20 ft. in thickness, but the mine was unfavourably situated for working, and has been closed. A small mine has since been opened in the Nilawan gorge, a little further to the west, below the village of Nurpur (32° 40′: 72° 39′).

At VARCHA 20 feet of salt are excavated from a bed of much greater thickness, the remainder being of comparatively poor quality. The old Sikh workings here were of great size, but of the usual dangerous character.

The salt of the Range is white or pink in colour, often laminated in layers of different tints. The composition is more complex than that of the Kohat salt, since it contains a certain proportion of foreign salts. An average analysis quoted by Christie (**314**—4, 243) gave:—NaCl=96·10: $MgCl_2$=0·60: Na_2SO_4=3·20: Insoluble matter=0·10 per cent.; and the average analysis of 4 samples quoted by Wynne (**1975**—18, 77):—NaCl=93·00: $MgCl_2$=1·25: $CaCl_2$=0·50: $CaSO_4$=0·75: Water and loss =4·50 per cent. According to Giraud (**661**—1), the red colouring matter consists of infusoria and confervæ, an observation that does not seem to have been confirmed (**B.** 484).

The average annual production of rock salt, during the quinquennial period 1909 to 1913, was 128,247 tons, of which about 100,000 tons annually came from the Mayo mines. In 1914 the output amounted to 138,542 tons, and in 1915 to 135,519 tons.

Kangra (Mandi)—The rock salt mines of Mandi State were first described by Moorcroft (**1246**, Vol. I, 159) in 1841, and a few years later by Jameson (**931**—3, 214) and Parish (**1363**—1, 289). In 1860 they were visited by Medlicott (**1197**—5, 60), who describes the salt as being of a dark purplish hue, quite opaque, and with a large admixture,—about 25 per cent.,—of earthy impurities. Small nests

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of pure crystalline salt are occasionally met with, and these are reserved for the use of the Raja and his household (**B.** 490).

The precise age of these deposits has not yet been determined. They occur in a zone of limestone, shales, and sandstone, supposed by Medlicott to belong to the Krol series, and much complicated by trappean intrusions, just within the boundary separating these rocks from the sub-Himalayan Tertiaries; but in the Manual, Geology of India (**1198,** 558) the opinion is expressed that the beds may be an abnormal development of the Subathu (nummulitic) group. Jameson (*l.c.*) compared them with the salt series of Kalabagh, in Mianwali, relying mainly upon the association of the salt with a band of bright red 'marls' and magnesian limestones.

The salt is quarried at two localities 14 miles apart, DRANG (31° 49′ : 77° 1′) and GUMA (31° 58′ : 76° 55′). The method of extracting the salt, as described by Jameson, is peculiar. Runnels of water are led across the face of the beds, and wear out channels in the salt, enabling the miners to break off large blocks with sledge hammers. The average annual output, during the five years 1909 to 1913, was 3,689 tons. In 1914 and 1915 the production amounted to 2,792 and 3,633 tons respectively.

Mianwali.—KALABAGH (32° 58′ : 71° 37′). The rock salt of this area occurs at the same horizon and under the same conditions as in the Jhelum and Shahpur districts, in what is, geologically considered, an extension of the Salt Range to the western side of the Indus. An account of the locality was given by Mohun Lal (**1234**—1) in 1838, when 21 quarries were being worked. The geology of the area has been described by Fleming (**591**—3, 687) and Wynne (**1975**—28, 246), and the mode of occurrence of the salt by Warth (**1892**—5). The red marl in which the salt occurs is exposed at the base of the hill on which the town is built, and extends northwards for about 2 miles up the valley of the Lun stream. The salt beds range from 4 ft. up to 10 or 20 ft. in thickness, and are worked in open quarries. The salt is usually of the same reddish colour as that of the Salt Range, but much of it occurs in transparent cubes measuring several inches on the side (**B.** 483).

The production from these quarries is included in the returns from the cis-Indus Salt Range.

RAJPUTANA.

Bharatpur.—Salt was formerly manufactured, to the extent of about 57,000 tons annually, in this State, but the industry was closed by arrangement with the Government of India in 1876 (*see*

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Hacket, **730**—3, 198). The process of manufacture, which was similar to that practised in the neighbouring district of Gurgaon, was described in 1832 by Hardie (**764**—6, 334). The brine was obtained from wells sunk in the alluvium to depths of 42 to 64 ft. that from depths of between 51 and 60 ft. being the richest in salt. The chief centres of the industry were situated at BHARATPUR (27° 13′ : 77° 33′), DIG (27° 29′ : 77° 23′), and KUMHER (27° 19′ : 77° 26′).

In Western Rajputana, salt is manufactured from brine occurring in natural depressions of the surface, which are in some cases converted into shallow lakes during the monsoon season, and wholly or partly desiccated during the ensuing hot weather. Several suggestions have been put forward in order to account for the existence of the desert salt, and the replenishment of the stores contained in the depressions. Blanford (**148**—48, 93) supposed that an arm of the sea may have extended in recent times up the valley of the Luni R., the water of which, when not in flood, is intensely salt; and that the Runn of Cutch is a remnant of this ancient gulf. Hacket (**730**—3, 202) thought that the salt of the lower ground might have been introduced by the large rivers of the Punjab, which, there is reason to believe, once flowed through Rajputana; and that at higher elevations the salt may be derived from concealed beds of rock salt in the Vindhyan series. Noetling (*see* Griesbach, **708**—34, 19), after an examination of the Sambhar lake, formed the opinion that the brine was supplied by springs rising along a supposed fault in the Arvali rocks beneath the silt which forms the floor of the lake; while La Touche (**1034**—28, 41) suggested that the salt brought down in solution by the rivers flowing from the Arvali range, instead of being carried into the sea in the usual way, is deposited on the surface of the desert as the water evaporates. The question has more recently been discussed by Holland and Christie (**860**), who have shown that there is either no evidence in support of these theories, or that the explanation they give is inadequate to account for the facts. Following up an observation by La Touche (**1034**—28, 39) that the fossil remains of foraminifera are carried inland by the wind from the limestone areas in Cutch to distances of over 300 miles, they instituted a series of quantitative tests, carried out in 1908 by Christie near Pachpadra, which showed that large amounts of salt must be carried into the desert area from the saline tracts surrounding the Runn of Cutch during the annual monsoon, when the prevailing winds blow from the S. S. W. The results of these experiments, which were made under conditions not entirely satisfactory, give some idea of the magnitudes involved. Assuming that

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all the salt is carried in the lowest 100 metre layer of the atmosphere, it was estimated that the quantity of wind borne salt brought into Rajputana during each hot weather season would be about 130,000 metric tons; and that during the same period of four months, about 36,000 metric tons would be brought into the drainage area of the Sambhar lake.

The following are the principal salt-producing localities in this region:—

Bikaner.—LONKARA SAR (28° 30′ : 73° 48′). No description of this salt source has been published, nor are any statistics of output recorded.

Jaipur.—KACHOR-REWASSA (27° 27′ : 75° 18′). This is a shallow depression, and was perfectly dry when visited by Hacket (**730**—3, 201) about the year 1880. No manufacture of salt was then being carried on.

SAMBHAR (26° 54′ : 75° 15′). The Sambhar lake is the largest of the Rajputana salt lakes, covering an area of about 90 sq. miles during the monsoon season. It lies in a depression surrounded on all sides by schists of the Arvali series, having a drainage area of about 2,200 sq. miles, and is fed by four rivers,—the Menda, Rupnagar, Kharian, and Khandel. During the hot season the lake becomes practically dry. Borings made in 1904 through the silt in the bed of the lake reached the floor of Arvali schist at depths of 61 to 76 ft.

Specimens of the silt from the bed of the lake were analysed by Prinsep (**1436**—26) in 1836, and found to contain:—NaCl=19·5: Na_2SO_4=10·4: Insoluble matter=70·0 per cent. Analyses made by Holland (**859**—3, 247) of four samples of the lake brine collected in March 1891 showed that the average quantity of solid salts present amounted to 25·89 per cent., and that the average composition per ton of salts was:—Sodic chloride 15 cwt. 2 qr. 7 lb.: Sodic carbonate, 1 cwt. 0 qr. 8 lb.: Sodic sulphate, 3 cwt. 1 qr. Traces of iodine and nitrates were found in all the samples, but the presence of boracic acid, which Warth (**1892**—17) thought that he had detected, was not confirmed.

From the results of a systematic sampling of the silt in the lake bed, carried out in 1905, it was calculated by Holland (**859**—56, 100) that the upper layer of 4 ft. contained 18,607,000 tons of salt, and that the proportion contained in lower layers down to 12 ft. was at least as great as this. At the same time it was pointed out that the practice of returning the bittern containing the sulphate

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and carbonate to the lake, after the extraction of the edible salt, must result in a depreciation of the quality of the brine, which derives its salt from the upper layer of silt. A scheme for the removal of the sulphate, by taking advantage of the great range of temperature that is available at Sambhar, was suggested by Holland (**859**—51, 147) in 1905.

The process of manufacture in operation at Sambhar has been described by Conolly (**349**—2) and Ashton (**44**, 120), and a description of the lake and its surroundings has been given by Woodburn (**1960**). The brine is evaporated by solar heat in shallow pans called *kyars*, until a point is reached when the solution is nearly saturated with the sulphate of soda, the chloride being then removed for sale. The average amount of salt sent annually from the lake, during the five years 1909 to 1913, was 179,907 tons (**B.** 478).

Marwar (Jodhpur).—DIDWANA (27° 24′ : 74° 38′). As described by Hacket (**730**—3, 201), this salt lake is about 4 miles long by 1½ broad, and is quite dry in the hot season. The brine is obtained from wells about 6 ft. in diameter, sunk through the silt in the bed of the lake to a depth of about 15 ft. The bottom of the well is pierced by an iron-shod pole to a further depth of 2 or 3 ft. when the brine rises suddenly to within 4 ft. of the mouth of the well. The brine is evaporated by solar heat in the usual way (**B.** 480).

FALODI (27° 17′ : 72° 28′). No description of this salt source has been published.

PACHPADRA (25° 56′ : 72° 13′). The manufacture of salt at this locality was described by Burnes (**235**—3) in 1833. Large pits or trenches are sunk in the bed of a depression, supposed to be a portion of an ancient bed of the river Luni. The salt was crystallised on the branches of a shrub called *Murari*, which were thrown into the brine and removed every third year.

The average annual production from this source, during the five years 1909 to 1913, was 27,956 tons.

UNITED PROVINCES.

Ghazipur.—Salt was formerly manufactured in this district from brine obtained by lixiviating saline soil. According to Stephenson (**1696**—1), the crude salt was calcined with cowdung and again dissolved and evaporated by solar heat. The crude product is said to contain 60 per cent. of salt.

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Jalaun.—At MARHAPUR (26° 24′: 79° 33′) salt was obtained from the damp sand of the Jumna R. Burt (**242**—2) gives a description of the process of manufacture, and says that 80 lb. of sand produced 1 lb. of salt. The spots where saline sand is procurable are said to be indicated by swelling up as the brine is evaporated by the heat of the sun.

SALTPETRE.

Although India no longer possesses a virtual monopoly in the production of the world's supply of nitrates, the saltpetre industry still attains considerable proportions. As Holland (**859**—50, 86) has pointed out, the conditions necessary for the formation of saltpetre in a soil, *viz.*—supplies of nitrogenous organic matter ; climatic conditions favourable to the growth of nitrifying bacteria ; the presence of potash ; and meteorological conditions suitable for the efflorescence of the potassium nitrate at the surface,—are ideally present in the Bihar section of the Gangetic plain, where there is a dense population using wood and cowdung as fuel, accompanied by large numbers of domestic animals, and living in a climate where the mean temperature is 76° F., with a diurnal range not exceeding 8° above or below 84° F., and a humidity of over 80 per cent. (*see also* Stephenson, **1696**—5; Watt, **1903**—4, 111; Hooper, **868**—3; Leather and Mukerji, **1044**).

The description of the method of manufacturing saltpetre in Tirhut, as given in 1833 by Stevenson (**1698**—1), and by the later authorities noted above, differs in no essential respect from that given in 1665 by Thevenot, quoted in the first volume of the *Philosophical Transactions* (**1764**). In November the efflorescent salt is scraped from the surface of old mud heaps, mud buildings, and waste ground, and is collected in heaps at the factories by the *luniyas* or native maunfacturers, or *shorawalas* as they are called in northern India. The salts are lixiviated in basin-shaped clay filters, 6 to 8 ft. in diameter, fitted with a false bottom of bamboo covered with grass mats. On these a layer of vegetable ashes is placed, and then the saline earth, which is trodden down till sufficiently firm to allow water to percolate slowly through the mass. The liquor is evaporated in rows of earthen vessels to the crystallising point, and is then removed to shallow earthen dishes, sunk to the brim in soft earth, where crystallisation is finished in about 30 hours. The crystals are taken out, allowed to drain, and stored for sale. The mother liquor is mixed with a fresh supply from the filters and returned to the evaporating pans (**B.** 499).

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The average composition of the saline earth, as determined by Stevenson, was :—KNO_3=0·7 : $CaCO_3$=44·3 : Na_2SO_4=2·7 : NaCl =1·4 : CaN_2O_6=0·9 : Insoluble matter=50·0 per cent. An average sample of the crude salt, taken from several hundredweight of good quality, yielded :—KNO_3=77·9 : Na_2SO_4=9·1 : NaCl=8·0 : Insoluble matter=5·0 per cent. The saltpetre is sold in its crude state and taken to refineries in Calcutta and elsewhere for purification before being exported. According to Ashton (**44**, 135), there were 33,997 factories of crude salt at work during 1898-99, and 13 refineries in Calcutta.

The process of manufacture is practically the same for all parts of India. For provinces other than Bihar and Orissa, particulars of the industry have been furnished by the following writers :—

BURMA.

Shwebo.—Strover (**1721**, 14) gives a list of localities situated in the 'dry zone' of Upper Burma, at which saltpetre was manufactured under Burmese rule. The average outturn, about the year 1873, is said to have been about 1,300 cwt. annually.

Shan States (S.).—Middlemiss (**1219**—22, 152) mentions the manufacture of saltpetre at NAM-TÔK (19° 59′ : 97° 1′) from nitrate-impregnated earth gathered from beneath the stalagmitic floors of caverns.

MADRAS.

Anantapur.—Newbold (**1294**—16, 142) gives a brief description of the process of manufacture at BELLAGUPA (14° 43′ : 77° 12′).

Coimbatore.—Newbold (**1294**—45, 773) states that saltpetre of excellent quality is extensively manufactured in the neighbourhood of COIMBATORE (11° 0′ : 77° 1′).

Guntur.—Heyne (**834**—2, 312) gives a general account of the process of manufacture. A large village may produce from 45 to 50 cwt. annually. At p. 234, BELLAMKONDA (16° 30′ : 80° 5′) is mentioned as one of the centres of the industry.

Kurnool.—In the Kurnool Manual (**675**, 99) it is stated that saltpetre is manufactured in MADDIKERAI (15° 15′ : 77° 29′) and MARKAPUR (15° 45′ : 79° 20′).

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Madura.—Nelson (**1286**, 24) gives details of the process of manufacture. The salt occurs abundantly on the sites of old villages. From 450 to 670 cwt. were produced annually about the year 1868.

Nellore.—Boswell (**174**, 67) gives a list of the Taluks in which saltpetre is produced and describes the process of manufacture. The annual outturn might amount to about 120 cwt.

PUNJAB.

Baden-Powell (**60**—1, Vol. I, 79) and Warnford-Lock (**1889**—1, 121) give general accounts of the saltpetre industry and describe the process of manufacture. Filtration is carried on until the liquor contains 2 or 3 per cent. of nitre, when it is evaporated in shallow iron pans. The crude product contains from 45 to 70 per cent. of potassium nitrate. The province is said to be capable of producing from 4,000 to 5,000 tons of saltpetre annually.

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Palmer (**1361**) describes the changes in the soil by which nitre is produced. The brine was evaporated in earthenware pans exposed to the sun and wind.

Milburn (**1224**, Vol. II, 238) has given statistics of the production of saltpetre in India during the years 1755 to 1809, when the sale was a Government monopoly. The average annual export during the years 1791 to 1805 is estimated to have been 55,323 bags, or about 80,000 tons. The average export for the years 1876 to 1880 (Ball, **71**—45, 500) was 417,659 cwt. Since that time a gradual decline in the quantity exported set in, the average for the five years 1909 to 1913 being 331,498 cwt. In 1914 the export fell to 285,156 cwt.; but in 1915 there was a decided recovery, owing to the demand for saltpetre for the manufacture of explosives, to 418,608 cwt.

Considerable quantities of saltpetre are imported from Nepal. For the five years 1909 to 1915, the average amount imported annually was 9,172 cwt.

SAMARSKITE *see under* **RARE MINERALS.**

SANDSTONE *see under* **BUILDING MATERIALS.**

SAPPHIRE *see under* **GEM-STONES.**

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SCHIST *see under* **BUILDING MATERIALS.**

SELENITE *see* **GYPSUM.**

SERPENTINE *see under* **BUILDING MATERIALS.**

SILVER *see* **LEAD.**

SLATE *see under* **BUILDING MATERIALS.**

SOAPSTONE *see* **STEATITE.**

SODA.

Reh. The saline efflorescence known as *reh* or *kallar*, which is commonly found on the surface of the soil in the drier parts of the Indian peninsula, is the only source, with one exception, of the indigenous supply of carbonate of soda. The origin of *reh* has been made the subject of much discussion, especially in connection with its deleterious effect upon the productive capacity of the soil, many tracts having been rendered unfit for cultivation by its growth within the last century. Full reports on this aspect of the question, and on the composition of the salts concerned, will be found in Vol. XLII of 'Selections from the Records of the Government of India' (**30**; **215**; **346**; **1197**—4; **1621**; **1717**—13; **1820**—2; **1918**), and in the 'Agricultural Ledger' (**520**; **835**; **1043**—2; **1249**—1; **1903**—4); also in papers communicated to other publications by Center (**295**), Fulton (**630**), Medlicott (**1197**—55), Oliver (**1332**—2), and Ward (**1888**).

The composition of the efflorescent salts varies considerably from place to place. Common salt and sulphate of soda are the most usual ingredients, but carbonate of soda is formed when no lime or magnesian salts are present in the soil. Nitrates are produced where the soil is charged with organic nitrogenous matter (*see* **SALTPETRE**). The salts are partly introduced by river water, but probably the greater portion results from the decomposition of the mineral particles composing the soil itself by water charged with carbonic acid, and the rearrangement of the chemical constituents. Where the soil is of a clayey nature and insufficiently drained, and especially where the rainfall is deficient, the salts accumulate in the subsoil water, and if this lies near to the surface, are brought up by capillary action during the hot dry season, crystallising out as an efflorescence as the moisture evaporates.

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The carbonate of soda, when present in sufficient quantity, was extracted by lixiviating the soil as in the preparation of saltpetre, and fractional crystallisation. Center (**295,** 272) has pointed out that the natural mixture of sulphate and chloride of soda occurring in *reh* resembles the product of the first step in the commercial manufacture of soda from common salt, and that the salt cake obtained by evaporating the brine could be converted into soda by heating it with charcoal and *kankar* (**B.** 496).

The following occurrences of carbonate of soda have been specially noted :—

ADEN.

Haines (**736**—1) states that carbonate of soda is to be found in unlimited quantities along the coast for 10 miles to the E. of Aden. It is accumulated in hollows beyond high water mark, into which sea water percolates through the limestone pebbles forming the beach. The crude salt contains :—Na_2CO_3=51·05 : NaCl=24·94 : H_2O= 19·66 per cent., with traces of sulphate of soda and magnesium chloride.

BIHAR AND ORISSA.

Martin (**1181,** Vol. I, 272) mentions the occurrence of an alkaline efflorescence at several places in the southern part of the Bihar division. The most extensive deposits were seen to the S. of NAWADA (24° 53′ : 85° 37′) and in SHEKHPURA, (25° 8′ : 85° 55′).

BOMBAY.

Gujarat.—The manufacture of alkali from saline earth found in parts of Gujarat is mentioned by Hove (**873,** 122).

Poona.—Sykes (**1736**—1, 426) mentions the occurrence of carbonate of soda at SIRUR (18° 50′ : 74° 24′) and LONI KALBHAR (18° 29 74° 5′ 30″).

CENTRAL INDIA AGENCY.

Gwalior (Malwa).—Stewart (**1701**—1) has recorded the occurrence of carbonate of soda on the margins of pools in the bed of the CHAMBAL R., where it traverses basaltic rocks at its junction near PIPLAUDA (23° 21′ 30″ : 75° 29′) with the Chamla (**B.** 495).

CENTRAL PROVINCES.

Buldana.—LONAR (19° 59′ : 76° 35′). The water of a shallow lake covering a portion of the floor of a circular crateriform hollow, 300 ft. in depth and about a mile in diameter, in the basaltic plateau surround-

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ing the village of Lonar, contains a large proportion of the carbonates of soda, which crystallise out on the drying up of the lake during the hot season, and are used in the manufacture of glass and soap. The physical aspects of the lake and its surroundings have been described by Alexander (**22**—1), Malcolmson (**1158**—5;—8, 562), Bradley (**187**—4), and Smith (**1658**). The origin of the hollow is probably to be attributed to volcanic action of some kind, but it has not yet been satisfactorily explained. According to the various theories proposed, it may be either the crater of an extinct volcano (Bradley, *l. c.*; Buist, **228**—15, xiv; Smith, *l. c.*); or it may be due to a single paroxysmal explosion (Blanford, **148**—21, 63; Oldham, **1324**—41, 19; —68, 147); or to the collapse of the central portion of a large 'blister,' elevated by the inrush from below of vapour or molten lava (Orlebar, **1341**—1, 37; Newbold, **1294**—38, 40; La Touche, **1036**, 272). Ball (**71**—45, 493) has suggested a non-volcanic origin, *viz.*, a subsidence caused by the falling in of a cavern supposed to have existed in the Lameta limestone, which at certain places is found cropping out from beneath the basaltic flows.

Analyses of the lake brine have been made by Alexander (*l. c.*), Reynolds (**1476**), Mayer (**1193**—3), Wallace (**1876**), Plymen (*Indian Trade Journal*, Vol. XIV, 228), and lastly by Christie (**314**—1). Six varieties of salt are collected from the bed of the lake as the water evaporates during the hot season, each containing the following percentage of soda, according to Plymen :—

——	*Bhuski.*	*Papri.*	*Khappal.*	*Dalla.*	*Dalla Nimak.*	*Nimak Dalla.*
Na_2CO_3 . .	32·72	23·19	24·09	46·90	33·05	11·67
$NaHCO_3$ . .	27·53	17·21	18·18	33·18	26·09	8·58
NaCl . .	3·35	41·99	37·45	..	24·25	71·11

The ratio of carbonate to bicarbonate corresponds very closely to that of the compound *urao* occurring in other soda lakes.

Christie estimated that in March, 1910, when the maximum depth of the lake was 2 ft., the water contained about 2,000 metric tons of sodium carbonate, and that the upper layer of lake mud, to a depth of 1·5 metre, would contain about 4,500 tons. Suggestions are put forward in his paper for the economical extraction of the soda salts, and the origin of the salts is discussed.

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Smith, writing in 1856, says that the lake had not been regularly worked since 1836, when the output was about 460 tons of soda. During the five years 1909 to 1913, the total amount of soda salts produced is estimated at 446½ tons (**862**, 289).

Wardha.—Wilkinson (**1933**, 291) mentions a deposit of *reh* at PAUNAR (20° 47′ : 78° 44′). The efflorescence is collected and used for washing clothes and making soap.

HYDERABAD.

Walker (**1868**—5, 187) says that an efflorescence of carbonate of soda is found at many places in the northern and eastern districts of the State, and is used by washermen and glass makers.

MADRAS.

Cuddapah.—Malcolmson (**1158**—2) describes a well at GANDIKOT (14° 49′ : 78° 20′ 30″), the water of which is alkaline and is used for fixing the colours in cloth. He also alludes to the use of efflorescent salts for glass making.

Salem.—Campbell (**272**—6) has given a description of the soda soils in the tract known as the Baramahal, an elevated plain in the N. W. portion of the district. The efflorescence occurs in patches of about half a mile square, lying on beds of *kankar*. The crude salt is obtained by lixiviating the soil and sprinkling the brine on layers of cowdung, which are dried in the sun. It contains about 75 per cent. of carbonate, with 23 per cent. of insoluble matter, and small quantities of common salt and sulphate of soda (**B.** 493).

MYSORE.

Chitaldroog.—About 21½ tons of soda are manufactured annually from saline earth at ANIVALA (13° 49′ 30″ : 76° 14′), according to Sambasiva Iyer (**1548**—7, 255). The process is similar to that practised in the Salem district, Madras.

Mysore.—Sambasiva Iyer (**1548**—11, 40) says that soda earth occurs extensively in the MANDYA (12° 32′ : 76° 57′) Taluk. A sample was found to contain 56 per cent. of sodium carbonate. About 120 tons are marketed annually.

UNITED PROVINCES.

Hill (**837**) has published analyses of *reh* salts from the tracts lying between the Jumna and Ganges rivers. None of the samples

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examined contained less than 88 per cent. of sodium carbonate. The percentage composition of samples from four districts was:—

	Pertab-garh.	Benares.	Mirza-pur.	Allahabad.	
				Trans-Ganges.	Trans-Jumna.
Percentage of soluble salts	6·3	3·1	16·6	6·3	6·5
Na_2CO_3	95·63	95·08	88·90	94·38	94·80
NaCl	3·39	4·40	1·20	1·21	1·75
Na_2SO_4	..	..	9·34	4·12	3·02

SPINEL *see under* **GEM-STONES.**

STEATITE *and* **POTSTONE.**

Talcose schist or potstone is widely distributed among the crystalline rocks of India, and is quarried at many places to be fashioned into bowls, plates, and other utensils, which are much esteemed by high caste Hindus because they can be purified after use by fire, and do not communicate an unpleasant taste to the food. Chloritic schists are occasionally turned to the same purpose, but are liable to fly to pieces when heated. The more compact forms of the mineral, soapstone or steatite, are carved into idols and ornamental articles, such as the delicately cut models of the Taj Mahal sold to tourists at Agra ; or, when of sufficiently fine texture and free from grit, are exported to be made into gas burners, or for other purposes to which ' French chalk ' is applied. A series of tests on samples from various localities was carried out by Mallet (**1159**—51) in 1889, and in the following year a note on the specimens selected and sent to England for practical trial was drawn up by Royle (**1530**), who reported that a sample from Maddavaram (15° 30′ : 78° 9′) in Kurnool had been found by Messrs. Sugg & Co. to be suitable for the manufacture of gas burners.

The average annual production of steatite in India, so far as returns are available, amounted to 1,011 tons during the five years 1909 to 1913. The amounts produced in 1914 and 1915 were practically the same.

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AFGHANISTAN.

Medlicott (**1197**—56), notes that specimens of fine white **steatite** are included in a collection of rocks from the flanks of SIKARAM (34° 2′ : 69° 58′), the highest peak of the Safed Koh (**B.** 444).

BENGAL.

Midnapore.—Blanford (**148**—2, 278) says that chloritic and serpentinous beds occurring among the gneissose rocks in the southern part of the district are largely used as **potstones**, or for fine carved work in the temples (**B.** 441).

BHUTAN.

Godwin-Austen (**669**—10, 121) and Mallet (**1159**—6, 35) mention the occurrence of fragments of pure soft **steatite** among slates in a ravine at BALLA (26° 53′ : 89° 25′), on the left bank of the Tursa R. The mineral has not been found *in situ* (**B.** 445).

BIHAR AND ORISSA.

Cuttack.—Stirling (**1706**, 179) states that **potstone** occurs in abundance among the NILGIRI HILLS in the N. E. portion of the district, and in the adjoining sub-State of **Keonjhar**, but does not mention any precise localities. It has been largely used in the decoration of the temples in Orissa (**B.** 441).

Gaya.—Sherwill (**1625**—4, 59 ; —6, 18) says that a dark blue variety of **potstone** is quarried from some small hills lying between the Rajghir and Barabar hills, and is fashioned into utensils at Gaya. A small quantity was also quarried from the BRAHMJUNI HILL, close to Gaya (**B.** 441).

Manbhum.—Magnesian schists are of common occurrence among the sub-metamorphic (Dharwarian) rocks traversing the southern part of the district, and are quarried and turned on rude lathes into cups, etc. Voysey (**1853**—7, 862) mentions a manufactory of cups from **potstone** at NARSINGHPUR (22° 45′ : 86° 30′), and Ball (**71**—46, 111) gives a list of 17 villages where quarries of potstone were situated, lying between MUTGODA (22° 47′ : 86° 58′) and MOISARA (23° 3′ 30″ : 86° 3′). **Potstone** also occurs at a few localities among the metamorphic rocks, and some masses are associated with intrusive basic rocks. Compact **steatite** is not known to occur in the district (**B.** 442).

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Mayurbhanj.—Potstones, resulting generally from the decomposition of dioritic-looking rocks, are found at several places, according to Bose (**173**—20, 173). The following occurrences are noteworthy :—

Three miles to the W. of GURGURIA, in the neighbourhood of SIMLIPAHAR (21° 52′ : 86° 27′).

NULUNGI, 5 miles to the W. of BALDIA (21° 58′ : 86° 41′). Utensils made here are said to find a ready sale in Baripada, the capital of the State.

TIRING (22° 31′ : 86° 8′), on the Dhalbhum border.

An output of 60 tons of steatite from this State is recorded in 1914, and of 50 tons in 1915.

Shahabad.—Sherwill (**1625**—5, 285) says that **potstone** of fine quality is quarried at PITEEAN(?), on the northern border of the Kaimur plateau, and is exported to Benares.

Singhbhum.—Potstone occurs at several places under the same conditions as in the adjoining district of Manbhum. According to Haughton (**785**—1, 117), the best quality is worked at DUBRAJPUR (22° 34′ : 86° 5′). Ball (**71**—46, 148) gives a list of villages at which quarries are and had been opened. Those being worked were :—

BELAIPAHARI (22° 49′ 30″ : 86° 22′). Old workings very extensive, many being 50 ft. deep.

DARI (22° 41′ : 86° 15′). Potstone occurs in distinct beds, with a northerly dip of 30 degrees. Shafts are numerous and generally from 20 to 30 ft. deep. The stone is soft and easily worked.

TIKRI, to the N. of GHATSILA (22° 34′ 30″ : 86° 33′). There are said to be about 100 more or less extensive quarries close to the village. The other localities mentioned are :—

DOMAPAL (22° 27′ : 86° 36′).
MUTIAGARA and SIDESHAR (22° 36′ 30″ : 86° 27′).
KORAIKELA (22° 42′ 30″ : 85° 36′).
PALAKUCHA (22° 36′ : 86° 4′).
TILAIJHOR (22° 35′ : 86° 18′)—(**B.** 442).

BOMBAY.

Dharwar.—Christie (**313**—1, 111) says that **potstone** is said to occur among schists in the S. E. part of the district. Besides being used for making cups, etc., it is mixed with lime to form plaster which is capable of taking a high polish.

Idar.—An extensive bed of **steatite** of good quality was discovered by Middlemiss (**1219**—30) in 1911 between the villages of DEV MORI

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and KUNDOL (23° 39′ : 73° 28′). The outcrop extends for more than a mile, with a width of over 200 ft., and practically vertical dip. The steatite is finely schistose in texture, of pale blue grey or pinkish grey colour by reflected light, and moderately hard. It is free from foreign material and can be easily cut into slabs and pencils. A softer, cream coloured variety also occurs, and harder bands that could be carved into durable ornaments. The quantity available to a depth of 20 ft. is estimated at over 2 million tons.

Beds of similar **steatite**, about 10 ft. in thickness, were also found to the N. W. of GHANTA (23° 36′ : 73° 26′). The outcrop extends for about 30 yards along the bed of a stream.

Ratnagiri.—Aytoun (**51**—3, 82) mentions a quarry in **potstone** at ASGANI (16° 13′ : 73° 40′ 30″), 10 miles from the sea coast at Malvan. Thick veins of **talc** were observed by Gibson (**654**—2, 143) cropping out in several places from beneath the covering of laterite. The stone was shaped into cooking utensils, etc.

BURMA.

Steatite is found in many places in association with masses of serpentine intrusive in the ' Chin shales ' or ' Axial group ' of the Arakan Yoma. Its mode of occurrence has been described by Theobald (**1763**—12, 43 ; —16, 336), who states that it is not confined to the serpentines, but that it is found also in the altered rocks along the margin of the intrusions. The following occurrences have been specially noted:—

Kyaukpyu.—The **steatite** mines situated between 3 and 4 days' journey (about 30 miles) to the W. of HPA-AING (20° 15′ : 94° 23′) in the Minbu district have been described in detail by Hayden (**793**—2). The steatite occurs in thin veins, expanding in places to 8 or 9 inches in width, ramifying through dark green serpentine, and liable to thin out and disappear at any moment. About 26 pits had been opened, of which four were in operation at the time of Hayden's visit. The passages are extremely narrow and tortuous, with no attempt at ventilation. A sample from this locality tested by Mallet (**1159**—51, 67) was of good quality, pale green in colour and compact, and cut freely.

Mallet also mentions (*l. c.*, 66) **steatite** mines at MYINGADÉ HILL (not shown on the map) in this district. A sample was similar in quality to that from the mines W. of Hpa-aing, but was contaminated with ferruginous impurity.

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Minbu.—An occurrence of **steatite** in serpentine near SENLAN (19° 54′ : 94° 23′ 30″), discovered in 1895, has been recorded by Hayden (**793**—2, 73). The steatite here is procurable in blocks half a cubic foot in size, and is said to be of good quality.

Prome.—Theobald (**1763**—12, 43) has described the occurrence of **steatite** at SHINBAIAN HILL (18° 57′ : 94° 56′). The mineral is said to be found in regular layers from 6 ins. to a foot in thickness, or in nodules enveloped in a matrix of fibrous quartz.

Sandoway.—**Steatite** is described by Theobald (**1763**—16, 338) as occurring on a low hill about 3 miles to the N. W. of SANDOWAY (18° 28′ : 94° 24′) in veins of fibrous quartz traversing shales and conglomerates. A small quantity of the mineral had been extracted, but only small pieces could be obtained of the fine quality used for writing purposes.

The production of steatite in Burma amounted on the average to 10 tons annually during the four years 1909 to 1912. Some of this output is said to have come from the Myitkyina district and the Pakokku Hill Tracts (**862**, 292), but no account of the occurrence of steatite in those districts has been published. Since the year 1912 the production appears to have ceased, probably because the use of steatite pencils, formerly universal in Burma, has been superseded by pen and paper.

CENTRAL PROVINCES.

Bhandara.—Hislop and Hunter (**843**, 380) note the occurrence of light coloured varieties of **potstone** at BIROLI (21° 24′ : 79° 54′) and DINI, near RAMPAILI (21° 40′ : 80° 4′). Pure white **steatitic schist** occurs at KANERI (21° 2′ : 80° 10′ 30″) and other localities to the E. of the Wainganga R. (**B.** 443).

A sample from Kaneri tested by Mallet (**1159**—51, 64) was of a buff colour, crystalline in texture, and intersected by occasional thin veins of crystallised talc along which the stone breaks easily.

Chanda.—An extensive development of dark coloured **potstone** with a metallic lustre, at JAMBAL GHAT (20° 33′ : 79° 31′) is mentioned by Hislop and Hunter (**843**, 380). The stone from this locality is said to have been specially reserved by the Mahratta authorities for carving into idols (**B.** 443).

Jubbulpore.—The occurrence of beds of **talcose schist** and **steatite** in a series of calcareous schists on the north side of the Narbada R. at

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the ' MARBLE ROCKS ' (23° 7′ : 79° 52′) was recorded by Medlicott (**1199**—3, 137) in 1860. According to Fermor (**577**—33, 263), the steatite forms pockets in the dolomite of the gorge. A sample from this locality examined by Mallet (**1159**—51, 64) was white with pale reddish blotches, and somewhat schistose. It cut very freely into slices with the foliation, but with difficulty across it.

The deposits are now being worked by Messrs. P. C. Dutt and by Messrs. Burn & Co. Concessions on the south side of the river at GOWARI (23° 6′ : 79° 58′) and LALPUR (23° 7′ : 79° 51′) have also been taken up by the Bombay Mining & Prospecting Syndicate (**862**, 291). The average quantity raised annually during the five years 1909 to 1913 was 476 tons. The figures for the years 1914 and 1915 were 502 and 329 tons respectively.

Yeotmal.—In the Berar Gazetteer (**1107**, 27), Lyall states that **soapstone** of fine grain and susceptible of a good polish is plentiful within a few miles of the town of WUN (20° 3′ : 79° 1′)—(**B.** 443).

HYDERABAD.

Heyne (**834**—2, 272) mentions the use of **steatite** for writing on wooden tablets, which were prepared by rubbing over with the juice of green leaves. When powdered it was used for imparting a gloss to the surface of fine plaster. The steatite was obtained from a place called ANANEGABAD (**B.** 441).

Warangal.—Walker (**1868**—4, 222 ; —5, 187) says that a coarse variety of **steatite** is frequently met with in this district. It was quarried and shaped into vessels at DAMENAPILLI (? 17° 45′ : 79° 35′) in the Vizianagar pargana, and at SIRKILLA (18° 23′ : 78° 53′) and MAITPALLI (?) in Aigundel.

MADRAS.

Anantapur.—Newbold (**1294**—16, 141) mentions that **potstone** is said to be quarried at REDORPILLI (?REDDIPILLI, 14° 43′ : 77° 45′).

Among the samples tested by Mallet (**1159**—51, 62) was one from NARJAMPALLI (14° 33′ : 78° 5′). It was of good quality, cutting very freely, compact and free from grit. It is said to be procurable in abundance.

Arcot (N.).—A sample of **steatite** from PATHUR (13° 15′ : 79° 4′ 30″) was among those tested by Mallet (**1159**—51, 63). It was pale green in colour and nearly compact in structure, but traversed by thin veins of crystallised talc which render it brittle. The specimen was free from grit and rather hard to cut.

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Bellary.—**Potstone** occurs in several parts of the district, according to Foote (**596**—39, 203), and has been largely used in the decoration of the temples. The most extensive deposit forms NILGUNDA HILL (14° 44′ : 75° 57′), and extends for 3 miles or more to the southward. A disused quarry of good grey potstone was seen at ANGUR (14° 57′ 30″ : 75° 49′) on the Tangabhadra R.; and unworked bands about a mile to the W. of HARAPPANHALLI (14° 48′ : 76° 2′ 30″), as well as a mass of rather coarse stone forming ARSAPUR HILL (14° 40′ : 76° 5′). On a low rise to the N. of this hill are several pits, from which greenish grey **steatite** of good quality was raised and shaped into bowls and platters. A similar stone was quarried for the same purpose at SOMALAPURAM (15° 2′ : 76° 34′). Samples from this locality tested by Mallet (**1159**—51, 62) were pale green in colour, somewhat crystalline in structure, and cut freely. Two of the samples were free from grit.

Outputs of 25 and 28 tons were reported from this district in 1914 and 1915 respectively.

Coimbatore.—Two samples of **steatite** from the Kollegal Taluk, one of which came from EDAMARANAHALLI (12° 5′ 30″ : 77° 26′ 30″), were pronounced by Mallet (**1159**—51, 63) to be rather gritty, but easily cut. Both samples were finely crystalline.

Kurnool.—DHONE (15° 23′ 30″ : 77° 56′). Newbold (**1294**—51 478) mentions the occurrence of beds of **steatite** of fine quality near the village. It was used in some quantity for making pencils.

MADDAVARAM (15° 30′ : 78° 9′). The occurrence near this place of thin layers of **steatite** among the shales of the Paupaghni group, or lowest member of the Cuddapah series, was noticed by King (**987**—7, 166) in 1872. The stone was quarried and made into pencils, paper weights, etc., at Kurnool. The quarries are said to cover a square mile in area. Some of the samples tested by Mallet (**1159**—51, 61) were of excellent quality, and were pronounced by experts in London (*see* Royle, **1520**) to be superior to any others sent from India. King (**987**—48, 2) remarks that the steatite beds are not more than 3 or 4 inches in thickness, and that blocks of the size required, 6 ins. cube, are not obtainable.

After thorough prospecting of the deposits here and at MUSILA CHERUVU, near BETAMCHERLA (15° 27′ : 78° 13′), a mining lease was secured by Mr. A. Ghose in 1912, and a market for the steatite was obtained in America. The output in 1913 amounted to 545 tons, and in 1914 to 210 tons. No returns appear to have been received for the year 1915 (**862**, 292).

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PENDEKALLU (15° 22′ 30″ : 77° 41′). **Steatite** quarries are said to be situated 7 miles from the railway station, and to cover an area of 10 acres. A sample tested by Mallet (**1159**—51, 62) was pale green in colour, and very slightly crystalline in structure. It was soft, easily cut, and free from grit.

In addition to these localities, **steatite** is mentioned in the Kurnool Manual (**675**, 97) as occurring at the villages of AMBAPURAM and BALAPALAPALLI, both of which are situated near Betamcherla.

Nellore.—A small production of **steatite**, amounting on the average to about 40 tons annually during the years 1913 to 1915, is recorded from this district. C. Æ. Oldham (*see* King, **987**—17, 163) noted the occurrence at JOGIPALLI (14° 13′ 30″ : 79° 47′ 30″) of highly talcose gneiss, which was quarried to a small extent and worked into small pots, figures, etc. Talcose schists are said (p. 134) to be well developed in a belt of schistose gneisses, exposed on the south side of the Pennair R. from KALUVAYA (14° 31′ : 79° 28′) to SAIDAPURAM (14° 11′ : 79° 48′).

Salem.—King and Foote (**988**, 324) mention a bed of **steatite** which crosses the Ishwaramalai, and is largely worked at TANDAGUNDAPALAIYAM (TANDAKAVUNDAN-PALAIYAM, 11° 33′ 30″ : 78° 27′), on the western side of the hill, where great quantities of utensils were being made. Specimens from this locality tested by Mallet (**1159**—51, 63) were pale grey in colour and rather gritty, containing disseminated crystals of dolomite and chlorite.

Campbell (**272**—17, 213) and Le Fanu (**1048**, Vol. I, 103) also mention the occurrence of extensive beds of **potstone** in this district. In addition to the locality noted above, ERUMAIPATTI (11° 9′ : 78° 21′), KARUPPUR (11° 43′ : 78° 9′), and SHORAGAMALLI (? SURAMANGALAM, 11° 40′ : 78° 10′) are specially mentioned (**B.** 440).

South Kanara.—A sample of **steatite** from MANAVALIKÉ (12° 47′ : 75° 26′ 30″), tested by Mallet (**1159**—51, 63), was pale buff in colour with reddish specks in places, and schistose in structure. It was free from grit, cutting easily in slices parallel to the foliation, but not across it. The quarries are said to cover 600 sq. yards.

Trichinopoly.—Muzzy (**1278**, 92) states that an extensive bed of **potstone** occurs between MUSIRI (10° 57′ : 78° 30′) and KANNANUR (11° 5′ : 78° 36′), and is quarried to be made into cooking utensils.

Vizagapatam.—Outcrops of coarse grey **potstone** were observed by Walker (**1872**—2, 168) at numerous places to the W. and S. W. of

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JEYPORE (18° 51′ : 82° 38′). It is worked near NOAPUR and ONTAGAON, about 3 miles from Jeypore, for building purposes and carving into idols. It occurs also on the Ramgiri road near MODPODOR (18° 46′ 30″ : 82° 23′). The largest masses were seen on the Malkongiri road, 5 miles beyond KOLAR (18° 42′ : 82° 26′ 30″). Here the potstone alternates with quartzites and well foliated biotite gneisses.

MYSORE.

Chitaldroog.—ANDANUR (14° 13′ 30″ : 76° 9′). The quarrying of **potstone** at this place is described by Sambasiva Iyer (**1548**—7, 256). The stone is mainly used for making water troughs for cattle.

UCHINGI DRUG (14° 45′ : 76° 51′). A band of coarse **potstone** is described by Foote (**596**—39, 34, 90) as occurrring between the granitoid gneiss forming the mass of Uchingi Drug and a narrow band of Dharwar rocks on the eastern side of the hill. The potstone contains numerous crystals of greenish white talc.

Hassan.—HALEBID (13° 13′ : 76° 3′). Large quarries of **potstone** at this place are mentioned by Foote (**596**—45, 72), who calls special attention to the value of the material as a decorative building stone (*see also* Newbold, **1294**—20, 19)—(**B.** 440).

Kadur.—SAKKAREPATNA (13° 26′ : 75° 59′). **Potstone** is quarried on a large scale here, according to Primrose (**1431**—8, 221), to be made into cooking utensils.

Mysore.—Primrose (**1431**—9, 156) has recorded the occurrence of two masses of **potstone** in the district :—

(1) To the S. of MUSANBAYANHALLI (12° 24′ : 76° 23′). The stone is of good quality, and has been used in the decoration of the Palace at Mysore.

(2) A quarter of a mile N. of TALUR (12° 12′ : 76° 40′). The outcrop covers a considerable area, but the stone is uneven in quality.

Shimoga.—**Potstone** quarries at KAVALEDURGA (13° 43′ : 75° 12′) are mentioned by Sambasiva Iyer (**1548**—7, 256).

RAJPUTANA.

Jaipur.—Samples of **steatite** from the following localities were among those tested by Mallet (**1159**—51, 64). The occurrences in

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the field have recently been examined by Heron (*see* Hayden, **793**—28, 21):—

(1) DOGETHA (27° 7′ 30″ : 76° 20′), 2½ miles to the N. E. of Raialo. Colour milk-white or faintly tinged with green; cuts very freely. The deposit is quite structureless, and is excavated over a width of 30 yards, along a length of 50 or 60 yards. Pieces up to a foot in length can be extracted.

(2) GISGARH (26° 53′ : 76° 42′). Colour green ; highly schistose in structure, and rather gritty in cutting. The bed is about 2 ft. thick. Slabs of large size are obtainable, but not more than 3 ins. thick.

(3) MORRA (26° 48′ 30″ : 76° 52′ 30″). Colour pale green ; very finely crystalline and somewhat schistose in structure. Cuts easily parallel to the foliation, but with difficulty across it. The deposit extends for 5 miles, the steatite occurring in pockets concentrated from talcose schists. One of the beds measures 25 ft. in thickness. According to Hacket (**730**—4, 250), the stone of which models of the Taj Mahal and ornamental carvings are made at Delhi and Agra comes from this locality (**B.** 443).

Traces of **steatite** were also observed by Heron in a well at KAWA (26° 46′ : 76′ 34′).

UNITED PROVINCES.

Almora.—A deserted **steatite** mine, situated about 4 miles to the S. of BAGESAR (29° 50′ 30″ : 79° 50′), is mentioned by Madden (**1151**—2, 230). The occurrence of soapstone at this locality was also noted by Hughes (**890**, 183). The mineral is said to occur in large detached masses.

Madden (**1151**—3, 596) has recorded the occurrence of **steatite** near the summit of THAKIL HILL (29° 30′ 30″ : 80° 16′) near Pithoragarh. The steatite is said to be of good quality.

Garhwal.—The occurrence of a white saponaceous stone at many places in Garhwal is mentioned by Traill (**1797**—3, 159), but no definite locality is specified. The stone is said to be turned into cups, etc., but being rather brittle it is little used.

An average annual production of 150 tons of steatite was recorded, during the five years 1910 to 1914, from the districts of **Hamirpur** and **Jhansi.** No description of these deposits has yet been published.

STRONTIUM *see under* **SULPHATES.**

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SULPHATES—COPPER.

RAJPUTANA.

Jaipur.—Blue vitriol, or sulphate of copper, has been manufactured for many years as a bye-product in the preparation of alum at the copper mines of KHETRI (28° 0′ : 75° 51′) and SINGHANA (28° 6′ : 75° 54′). The process has been fully described by Brooke (**203**—2, 525). The shale from the mines, mixed with the efflorescent crust that forms on the refuse heaps of previous lixiviations, is steeped in water. The liquor is then boiled, and when sufficiently concentrated sticks are introduced, on which the blue vitriol crystallises. The outturn is said to be about 8 lb. of sulphate from about 10 cwt. of the mixed shale and refuse. Heron, who visited the mines in 1913 (*see* Hayden, **793**—31, 19), says that although the production of copper has ceased, the manufacture of alum and of copper and ferrous sulphates is still carried on (**B.** 431).

IRON.

BALUCHISTAN.

Jhalawan.—Hooper (**868**—2) has described specimens of **melanterite** or **copperas** from Jhalawan, where it occurs in several places as an efflorescence on pyritous shales, and is used in dyeing in conjunction with pomegranate husk to produce black or deep green colours. Samples from the LADON PASS and KIL CHOTOK, in the neighbourhood of KHOZDAR (27° 49′ : 66° 37′), contained 30·1 and 27·36 per cent. of anhydrous ferrous sulphate respectively, with about 4 per cent. of alumina and 3 per cent. of sulphate of lime.

Vredenburg (**1854**—1, 278) has described a series of andesitic lavas and tuffs in the neighbourhood of the extinct volcano KOH-I-SULTAN (29° 10′ : 62° 45′), which have been altered by solfataric action into lithomargic clays, some of which, known locally as *mak* or *giri*, of a pale yellow colour, contain sulphates of iron and alumina. The iron salts are used in combination with certain vegetable substances and alum to form dyes of various colours.

Zhob.—Hutton (**900**—8, 597) says that sulphate of iron is brought from the Kakar district, lying to the north of the Zhob valley. It was used for watering and polishing the blades of swords.

BIHAR AND ORISSA.

Shahabad.—Sherwill (**1625**—5, 284) and Mallet (**1159**—3, 121) mention the occurrence of an efflorescence of sulphate of iron on the

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surface of the black pyritous Bijaigarh shales, exposed at the base of the scarps of Kaimur sandstone in the neighbourhood of ROHTASGARH (24° 38′ : 83° 58′). A sample of the crude salt, purchased in the Patna bazaar and analysed by Stevenson (**1698**—3), contained 39 per cent. of sulphate of iron, 36 per cent. of iron peroxide, and 23 per cent. of magnesia. It was used by the native dyers (**B.** 419).

BURMA.

Amherst.—A copious efflorescence of sulphate of iron on the surface of beds of lignite exposed near the source of the Ataran R. is mentioned by O'Riley (**1340**—2, 395).

Myingyan.—Pascoe (**1369**—1, 249) mentions the occurrence of an efflorescence of ferrous sulphate, mixed with ferric sulphate, on moist porous Miocene sand exposed in the KYAUNG MA, near SATTEIN (21° 3′ : 95° 19′). The compound salts are used by the Burmese for medicinal purposes.

PUNJAB.

Mianwali.—Shales containing ferrous sulphate and alumina, associated with alum shales exposed in the CHITTA WAHAN, near GARHI or PAI KHEL (32° 47′ : 71° 38′ 30″), are mentioned by Wynne (**1975**—18, 302). According to Baden-Powell (**60**—1, Vol. I, 66), the shale is steeped in the mother liquor from which alum has crystallised, and is then spread out to dry in the sun. The process is repeated, and the efflorescent salt, called *kahi*, is used for dyeing leather or cloth grey or black.

UNITED PROVINCES.

Almora.—Herbert (**827**—6, 229) says that an efflorescence of sulphate of iron occurs abundantly at the hot springs in the valleys of the Ramganga and Garjia rivers.

Mirzapur.—Sulphate of iron occurs in a ravine at UMLAH GHAT (24° 32′ : 83° 19′) under the same conditions as near Rohtasgarh, in the neighbouring district of Shahabad. Osborne (**1345**, 844) mentions a *kasis* (copperas) mine at this locality.

MAGNESIUM.

BENGAL.

McClelland (**1117**—24, 256) gives directions for the preparation of **Epsom salts** from the bittern or mother liquor produced at salt works in the Calcutta Salt Agency. The bittern is said to contain 4·8 per cent. of magnesium chloride.

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MADRAS.

Salem.—An experiment in the preparation of **Epsom salts** from Salem magnesite is described by McClelland (**1117**—28). It was found that 38lb. of the calcined magnesia would yield 144 (? 114) lb. of the sulphate.

PUNJAB.

Jhelum.—A lenticular bed containing potash salts associated with **kieserite,**—hydrous sulphate of magnesia,—was discovered by Warth (**1892**—8, 408) in the Mayo Salt Mines at KHEWRA (32° 39′ 30″ : 73° 4′). The kieserite, according to Tschermak (**1808**—7, 136), occurs in grains with a maximum diameter of 12mm., and in places appears to be compact. Two specimens analysed by Tween (*see* Wynne, **1975**—18, 80) yielded 7·78 and 58·02 per cent. of magnesium sulphate respectively (**B.** 437).

Other occurrences of the same nature in these mines have been described by Christie (**314**—4, 243).

Kangra.—A copious efflorescence of sulphate of magnesia was observed by Mallet (**1159**—1, 160) on the surface of the black pyritous slates from which the gypsum deposits near SHALKAR (32° 0′ : 78° 37′) and other localities in Lower Spiti have been derived (**B.** 437).

SODIUM.

BIHAR AND ORISSA.

The saline efflorescence known as *reh* or *kallar* (*see* **SODA**) usually contains a considerable proportion of sulphate of soda or Glauber's salt. Specimens from Tirhut analysed by Stephenson (**1696**—2) yielded 58 per cent., and from Cawnpore, analysed by Spry (**1687**—1), 50 per cent. of this salt. Watt (**1903**—4, 135) has given a brief account of the method of preparing Glauber's salt by lixiviation and evaporation of the efflorescence (**B.** 495).

An average annual output of 17,731 tons of sodium sulphate, obtained as a bye-product in the manufacture of saltpetre, is included in the returns from the districts of **Champaran, Mozaffarpur,** and **Saran,** during the years 1908 to 1913.

BURMA.

Shan States (N.).—The water of the saline well at BAWGYÔ (22° 35′ : 97° 17′), described under the heading **SALT,** contains an appreciable amount of sodium sulphate. It was estimated by La Touche (**1034**—32, 100) that the well, if worked to its fullest capacity, might produce about 70 tons of the sulphate annually.

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PUNJAB.

Jhelum.—Tschermak (**1808**—8) has described an occurrence of **glauberite** in the Pharwala seam at the Mayo Salt Mines, KHEWRA (32° 39′ 30″ : 73° 4′). The glauberite is found in crystals from 1 to 2 cm. in length, forming druses on rock salt.

RAJPUTANA.

Jaipur.—The existence of a considerable proportion of sodium sulphate in the brine of the SAMBHAR LAKE (26° 54′ : 75° 15′) has been mentioned under the heading **SALT.** Holland (**859**—3, 247) found that average samples of the brine contained 3 cwt. 1 qr. per ton of the total salts, and has suggested (**859**—51, 147) a scheme for the recovery of the sulphate from the bittern, instead of returning it to the lake, as has hitherto been the practice.

STRONTIUM.

BOMBAY.

Sind.—Blanford (**148**—63, 196) mentions the discovery by Fedden of crystals of **celestite**,—strontium sulphate,—sparingly scattered over the surface of the Khirthar limestone hills of the Kohistan, especially on the eastern side of the range E. of THANO BULE KHAN (25° 22′ : 67° 53′ 30″). The mineral occurs in crystalline nodules the size of walnuts (**B.** 474).

NORTH-WEST FRONTIER PROVINCE.

Kohat.—Wynne is reported to have found **celestite** in red clays of Tertiary age near SURDAG (33° 6′ 30″ : 70° 59′). It did not appear to be abundant (**B.** 474).

(*See also* **ALUM, BARYTES,** *and* **GYPSUM.**)

SULPHUR *and* SULPHIDE ORES.

Sulphur was formerly produced at a number of places in India and Burma, either from deposits formed by the natural decomposition of pyritous minerals in the neighbourhood of hot springs, or by distillation from iron pyrites; but only on a comparatively small scale for use as an ingredient in gunpowder or fireworks. No adequate attempt has yet been made to ascertain whether these indigenous deposits are suitable for the manufacture of sulphuric acid, which, as Holland has pointed out (**859**—50, 117), is the key to most chemical and many metallurgical industries. Without an abundant supply

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of this acid, the country is unable to utilise to the fullest extent many of its raw materials, or the bye-products rendered available in increasing quantities by the development of the coal and iron industries ; but is compelled to satisfy the demand for chemicals by importations obtained, at a cost of several millions sterling annually, from foreign sources of supply. A certain quantity of sulphuric acid is manufactured for special purposes at works installed in Calcutta and Rangoon, but in each case the raw material employed is imported.

The following occurrences of native sulphur, or of the minerals from which it might be obtained by distillation, have been observed (*see also* **ALUM, COPPER, LEAD,** and **ZINC**) :—

AFGHANISTAN.

Drummond (**504**—2, 92) remarks that sulphur is said to be found in great abundance in the Hazara Jat, but does not mention any precise locality (**B.** 157).

Nodules and small veins of sulphur were observed by Hayden (**793**—22, 37, 66) in gypseous shales occurring near the base of the Tertiary group in the neighbourhood of DASHT-I-SAFED (35°. 20′ : 67° 55′) in Kahmard.

ASSAM.

Lakhimpur.—MAKUM (27° 18′ : 95° 41′). Pyritous shales are associated in large quantities with the coal seams of Upper Assam (*see* Mallet, **1159**—9, 361), but it is doubtful whether they contain a sufficiently high proportion of sulphur to be profitably worked as a source of supply.

BALUCHISTAN.

KOH-I-SULTAN (29° 10′ : 62° 45′). The andesitic lavas and tuff beds surrounding the extinct volcano of Koh-i-Sultan are described by Vredenburg (**1854**—1, 278) as having been altered by solfataric action into brilliantly coloured, soft clays, impregnated with gypsum and occasionally sulphur. This is extracted by heating the clay in large caldrons over a fire of brambles. As the sulphur melts the lighter impurities are skimmed off with a flat iron ladle, the heavier ones sinking to the bottom. The sulphur is finally decanted into basin-shaped moulds.

Bolan Pass.—Tipper (**1787**—5) mentions the occurrence of sulphur in massive limestones of upper Cretaceous age at DRAJ BENT and GOKURTH, but the outcrops are much obscured by sinter deposits.

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Kachhi.—SANNI (29° 9′ : 67° 37′). Sulphur was formerly mined on a somewhat extensive scale at this locality. Hutton (**900**—8, 564), who visited the mine in 1846, says that there were several chambers entered by adits, and that the mineral was abundant, occurring both in a massive form and in crystalline aggregates of octahedral prisms. The crude sulphur was taken to Bagh, 40 miles to the E. of Sanni, to be purified, according to Masson (**1189**—2, 463), by boiling with oil. The mines are said to have been worked by the Amir of Afghanistan, but were closed at the time of the British occupation, and have been partly destroyed by fire. In 1906 the mine was inspected by Tipper (**1787**—5), who says that the sulphur occurs in veins and impregnations in Siwalik clays, and that some of the bands are so filled with it that they burn with ease. Holland (**859**—60, 51) remarks that the amount of sulphur impregnating the rock seems quite sufficient to hold out prospects of remunerative working (**B.** 157).

Las Bela.—Vredenburg (**1854**—36, 208) mentions the occurrence of sulphur in connection with a number of intensely saline springs near KAN BERAR (25° 29′ : 66° 3′), at the southern end of the range dividing the Porali from the Pohr R. west of Sonmiani. Veins of sulphur and salt were seen in the sandstone cliffs overlooking the springs, but the amount exposed is small and probably not of economic value.

Mekran.—Goldsmid (**673**—1, 203) remarks that much sulphur is procurable at GOLKURT near KARGHARI (25° 27′ : 64° 9′), on the Mekran coast.

Sibi.—Crystals of sulphur occur in considerable quantities, according to Townsend (**1794**—1, 208), in the stalagmite deposited by hot springs near the petroleum wells at KHATTAN (29° 34′ : 68° 31′).

BARREN ISLAND.

The deposits of sulphur on the volcanic cone of BARREN I. (12° 17′ : 93° 51′), which has been in a solfataric stage of activity since the early years of the last century, appear to be too small in extent to be workable on a commercial scale. It was pointed out in 1858 by von Liebig (**1070**, 304) that although the deposits on the upper two-thirds of the cone appeared to be large, it is doubtful whether they would be renewed with sufficient rapidity to enable them to be worked continuously. Mouat (**1263**—2, 114) and Ford (**602**, 215) considered that the amount available is very small, and this

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opinion was endorsed by Ball (**71**—16, 88; —41, 25), who says that deposition proceeds only at the summit of the cone, and that it takes place very slowly. Mallet (**845**, 278) found that the deposit was quite superficial, not more than 2 or 3 ins. in average thickness, and roughly estimated the quantity available as not exceeding a few dozen tons. He also found that the ash beneath contains only an insignificant proportion of sulphur. Finally Prain (**1424**—1), writing in 1891, states that the deposit accumulated at the principal solfatara since the year 1884 was only 2½ ins. in average thickness, and that the crusts formed at the two vents next in size did not exceed one inch (**B.** 161).

BIHAR AND ORISSA.

Mayurbhanj.—Bose (**173**—20, 170) remarks that iron pyrites is disseminated in some abundance through talcose and trappean schists at several places. The MALAMGHATTI PASS (22° 29′ : 86° 13′) on the Dhalbhum frontier is specially mentioned.

Singhbhum.—The sulphide ores of the Singhbhum copper belt (*see* **COPPER**) are a potential source of sulphur, which could be extracted as a bye-product in case it should be found possible to work the deposits on a large scale.

BOMBAY.

Sind.—GHIZRI BUNDER (24° 48′ : 67° 8′). The discovery of an apparently extensive deposit of sulphur at this locality was reported in 1843 by Preedy (**1427**). The crude material is stated by Blagrave (**140**—2) to contain from 30 to 40 per cent. of sulphur, and specimens examined by Piddington (**1405**—17) contained 60 per cent. (**B.** 156).

LAKI (26° 16′ : 67° 57′). Vicary (**1845**—5, 342) states that sulphur was manufactured by the villagers from the scum formed on the water of the hot springs near this place. According to Blagrave (**140**—2), it does not occur in payable quantities.

BURMA.

Strover (**1721**, 14), writing in 1873, says that the annual production of sulphur in Upper Burma, under Burmese rule, was about 28,000 viss (=about 912 cwt.). It was distilled from nodules of pyrites found at several places, of which a list is given, in blue Tertiary clays at a depth of 12 to 20 feet from the surface. According to Jones (**952**—4, 194), the principal centre of the industry was situated

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near MAWSŪN (20° 57′ : 96° 47′) in the Southern Shan States. Middlemiss (**1219**—22, 152) also alludes to the manufacture of sulphur and says that it is still carried on in the Bawzain (Mawsūn) State, and at YEBOK (?) in the Pwehla State.

Shan States (N.).—Several quartz veins carrying large quantities of iron pyrites have been found by Coggin Brown (*see* Hayden, *Records, G. S. I.*, Vol. XLVII 24) at HUNGWE (23° 7′ : 97° 11′) and near MAN PAT (23° 12′ : 97° 11′) in the Tawng Peng State. The pyrites contain no gold or other valuable metal, and the inaccessible nature of the locality renders the discovery of no value at present as a source of sulphuric acid.

HYDERABAD.

Gulbarga.—A limestone bluff at MUDNOOR (MUDANUR, 16° 36′ : 76° 33′) is mentioned by Meadows Taylor (**1751**—2, 31) as abounding in pyrites, from which sulphur was extracted.

KASHMIR.

Baltistan.—Several of the hot springs in this district are said to deposit sulphur. *See* **MINERAL WATERS**:—BISIL (35° 52′ 30″ : 75° 27′); DUCHIN (35° 28′ : 74° 51′); and KHORKUN (35° 20′ : 76° 50′).

Rupshu.—PUGA (33° 14′ : 78° 25′). Sulphur was formerly obtained by the Kashmir Government from deposits connected with the hot springs situated in the Puga valley. A brief description of the mines has been given by Cunningham (**399**—5, 234), who visited them in 1846, and noted the association of the sulphur with masses of gypsum. According to a more detailed account by Mallet (**1159**—1, 162), the ' mines ' were mere holes about 8 ft. in depth, from the bottom of which short passages were driven laterally. The rocks consist of thinly foliated and greatly contorted mica schist intersected by many small clefts and fissures, in which the sulphur is deposited either in a massive form, or coating the walls with transparent crystals. It also occurs in laminæ along the foliation planes, or disseminated in crystals through irregular masses of gypsum imbedded in the schist. There was a considerable fluctuation in the annual yield, chiefly dependent upon the weather, since at this elevation (14,500 ft.) work could only be carried on during four months in the year. It was said to amount to 20 or 25 tons (**B.** 159).

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MADRAS.

Arcot (S.).—An efflorescent deposit of sulphur is mentioned by Newbold (**1294**—19, 249; —45, 762) as occurring at a swamp in the 'Wodiapolliam jungle,' a few miles to the S. of WOLUNDERPET (=KIRANUR, 11° 41′ 30″ : 79° 21′). The sulphurous tract is said to extend for half a mile.

Godavari.—Heyne (**834**—1; —2, 186) has recorded the occurrence of a deposit of sulphur on the bed of a tidal swamp at 'SURA SANY YANAM' (SURISANIANAM, 16° 29′ 30″ : 82° 9′). It is said to be formed as a loose deposit or in nodules when the water dries up. A sample which perhaps came from this locality (*see* Mallet, **1159**—50, 7), analysed by Dr. McNally, contained 28·32 per cent. of free sulphur and 0·28 per cent. of combined sulphur (**B.** 156).

Travancore.—Masillamani (**298**, 13, 30) has described an occurrence of pyrrhotite on Mangamalai hill, about 2 miles to the W. of ARUMANALLUR (8° 19′ : 77° 28′). The mineral apparently occurs in the form of lenticular masses or discontinuous veins in charnockite, and indications of its presence were traced for a distance of 2 miles. The largest ore body opened up measured about 10 ft. in length and 8 ft. 6 ins. in width, and was followed to a depth of 8 ft. Another vein, 2 to 3 ft. broad, was found a short distance to the west.

NORTH-WEST FRONTIER PROVINCE.

Kohat.—Sulphur pits were formerly worked in a band of pyritous (alum) shales lying below a limestone scarp on the western bank of the Indus R. near Kushalgarh. The mode of occurrence of the mineral at LUNI-KI-KASSI (33° 36′ : 72° 1′) and at the petroleum springs of PANOBA (33° 37′ : 71° 58′) was described by Lyman in a supplement to his report on the Punjab oil lands (**1112**—1); and at GUNJALLI (33° 25′ : 71° 50′) by Wynne (**1975**—15, 203). The sulphur is produced by the decomposition of the pyrites in the shales, which appear to be very carbonaceous, and collects in its native form on the sides of small crevices in the rock. It was extracted by a simple process of sublimation in earthen vessels, one being placed on the fire and another inverted over it mouth to mouth, so as to catch the fumes (**B.** 157).

Shirani.—Traces of sulphur were observed by La Touche (**1034**—20, 96) in upper nummulitic beds near DOMUNDA (31° 36′ : 70° 14′), apparently formed by the decomposition of iron pyrites.

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PUNJAB.

Dera Ghazi Khan.—Ball (**71**—19, 157) states that sulphur was manufactured in the SORI PASS (30° 15′ : 70° 33′), where it is associated with gypsum, apparently deposited by a hot spring. Its occurrence at the SANGARH PASS (30° 42′ : 70° 32′), 20 miles further to the north, is mentioned by Blanford (**148**—73, 228, 230), who suggests that this is the pass to which Ball refers. It is possible that sulphur occurs at both localities, as they are situated on the same band of Eocene rocks. The crude ore consists of amorphous gypsum penetrated by strings and veins of sulphur, which was extracted by sublimation, as in Kohat (**B.** 157).

Blanford (**148**—73, 212) also states that sulphur is said to be found in whitish beds, probably of Eocene age, on the south side of GANDAHARI HILL (29° 6′ : 69° 46′). The deposit was not visited and had not been worked.

Jhang.—Vredenburg (**1854**—12) has described specimens of a jaspideous rock from the Kirana hills, containing numerous masses of pyrrhotite measuring a centimetre or more in diameter. The specimens were found by Mr. F. E. Cole in a quarry at HUNDIWALA (31° 55′ : 72° 38′), close to the railway station.

Mianwali.—According to Oldham (**1326**—49, 156), small deposits of sulphur invariably accompany the petroleum of the Punjab. Fleming (**591**—5, 347) and Bowring (**183**—1, 61) mention the occurrence of sulphur, associated with gypsum, at the petroleum springs near JABA (32° 52′ : 71° 44′). The quantity observed did not appear to be large, though it was distributed over a space of about 2 miles along the strike of the rocks (**B.** 158).

Rawalpindi.—Vicary (**1845**—6, 43) states that sulphur mines are said to have been worked in the hills lying to the east of the MARGALA PASS (33° 42′ : 72° 53′).

UNITED PROVINCES.

Dehra Dun (Jaunsar).—Herbert (**827**—6, 229, 258) says that sulphur occurs in considerable quantities in some of the galleries in the lead mines at MAIWAR (?) on the Tons R. The yield is said to have been sufficient to pay the expense of smelting the lead ore (**B.** 160).

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Kumaon.—Sulphur is deposited by some of the hot springs in this region, but in small quantities only. The following occurrences have been recorded :—

At hot springs in the bed of the RAMGANGA and GARJIA rivers. —Herbert (**827**—6, 229).

At hot springs at the mouth of the JAWAR or NITI PASS.—Traill (**1797**—4, 17).

At MANSIARI (30° 6′ : 80° 19′); near NANDPRYAG (30° 20′ : 79° 23′); and in Mulla Dasoli and Mulla Nagpur.—Lawder (**1040**—1, 88).

SYLVITE *see* **POTASH SALTS.**

TALC *see* **STEATITE.**

TANTALITE *see under* **RARE MINERALS.**

THORIUM *see* **MONAZITE.**

TIN.

BIHAR AND ORISSA.

Hazaribagh.—CHAPPATAND (24° 40′ : 86° 0′ 30″). A specimen of cassiterite-granulite, obtained by Mr. C. Jambon from this locality, has been described by Fermor (**577**—11). The cassiterite occurs in crystals of about equal dimensions with the other constituents of the rock, but sometimes forms aggregates to the exclusion of the other minerals. The proportion of cassiterite present is from one-third to one-half of the mass.

NURUNGA or NURGO (24° 10′ : 86° 8′ 30″). The occurrence of tin ore here was noted in 1849 by McClelland (**1117**—33, 19), who says that the ore occurs in nodules ranging to more than an ounce in weight, disseminated through gneiss. Mallet (**1159**—7, 35) describes an attempt made about the year 1867 to work the deposit, and says that the ore forms three or four lenticular beds in gneiss seldom more than a foot or two across, but in places reaching a width of 13 ft. The lateral extension was about 20 yards, nearly parallel to the foliation of the gneiss. The beds were followed to a depth of about 60 ft. by an inclined gallery, when work was stopped on account of the decreasing value of the ore and the influx of water (**B.** 314).

A more recent experiment in mining the deposit has been described by Oates (**1315**, 445). A shaft was sunk to a depth of 614 ft., but below 568 ft. the ore body was cut out. A sample of the ore

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yielded 1·87 per cent. of tin. The estimated yield per ton of ore was about 268 lb. of metal, but in practice it amounted to about half of this, as the ore was much contaminated with gangue and iron.

According to Fermor (*see* Hayden, **793**—26, 79), the ore is cassiterite-granulite, forming a thin layer in a much thicker band of microcline-granulite, which also contains sparsely scattered granules of cassiterite. The thin layer often contains from 30 to 50 per cent. of cassiterite.

SIMRATARI (24° 39′ : 85° 50′). A few crystals of tin-stone were found here by Mallet (**1159**—7, 43) in a lenticular pocket of granite in mica schist. Small grains of cassiterite were also detected in a dyke of lepidolite-granite exposed a little to the S. W. of PIHIRA (24° 38′ : 85° 52′)—(**B.** 315).

BOMBAY.

Dharwar.—Minute grains of oxide of tin have been detected by Foote (**596**—11, 140) in the streams draining the northern portion of the Kapatgod range near DAMBAL (15° 18′ : 75° 50′). The ore was associated with native copper and silver (**B.** 315).

Palanpur.—Holland (**859**—43) has recorded the discovery by Babu Baidyanath Saha of cassiterite at HOSAINPURA (24° 16′ : 72° 36′) in this State. The mineral is associated with gadolinite, and occurs in distinct, large crystals as a constituent of tourmaline pegmatite.

Rewa Kantha (Narukot).—A sample of tin-stone, said to have been obtained at JAMBUGHODA (22° 22′ : 73° 48′), was forwarded to the Geological Survey Office by Mr. Rogers. Nothing is known regarding its mode of occurrence (**B.** 315).

BURMA.

The tin ore deposits of Burma are invariably found in the neighbourhood of intrusive bosses of granite, which forms the core of many of the hill ranges running northwards from the Federated Malay States,—whence a large proportion of the world's supply of tin is obtained,—through Tenasserim, as far as Karenni in lat. 19° (*see* Bose, **173**—17). Beyond this, tin ore has not been detected in the granites of the Shan States or in the alluvial gravels derived from them, but it reappears under the same conditions in Yunnan, where tin mining is said to be extensively carried on. The earliest allusion to the existence of tin in Burma was made in 1599 by the traveller

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Ralph Fitch (**589**, 262; **1538**, 178), who remarks that on his journey from Pegu to Malacca he passed by "many of the ports of Pegu, as Martauan, the Iland of Taui (Tavoy), from whence commeth great store of tinne, which serueth all India."

Up to the present time practically the whole of the ore produced in Tenasserim has been obtained from the alluvial deposits resulting from the degradation of the granitic ranges; and these will probably yield the chief supply for a considerable time to come. For the rocks are so effectually concealed by vegetation and detrital material that the search for ore bodies or lodes,—if any such exist of sufficient richness to warrant expenditure on regular mining operations,—is a matter requiring much time and labour.

Until the early years of the present century, the exploitation of the alluvial deposits was entirely in the hands of Chinese and Siamese settlers. One attempt was made about the year 1873 to work the gravels and lodes at Maliwun in Mergui under European supervision, but after three years of hard work, in one of which 17 tons of cleaned ore and 7 tons of metal were exported, the concessionaires, Messrs. Strang, Steel & Co., resigned their lease. The conditions under which the native industry was carried on, and the mode of occurrence of the ore, have been described by the following writers :—

1829. Low (**1097**—2, 148). A brief notice of the stream tin deposits in Tavoy. Further details and an account of the native method of working are given in the *Journal, Roy. Asiatic Soc.*, Vol. III, p. 47.

1839. Helfer (**808**—5, 29). Gives results of prospecting operations in Tavoy and Mergui. The amount of oxide of tin in the gravels was found to range between 1 and 7 per cent.

1841-43. Tremenheere (**1302**—2; —4; —6). Full reports on the results of prospecting operations in Mergui. Details are given of the amount of tin ore obtained by washing at various localities. The second paper contains an account of a supposed lode of tin ore in granite at Kahan hill, near Mergui.

1843. Royle (**1529**—4). A brief account of the geology of Tenasserim, with remarks on the tin ore deposits mainly compiled from Helfer's and Tremenheere's observations.

1846. Tremenheere and Lemon (**1303**). A summary of the reports noted above.

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1849. O'Riley (**1340**—3). Enumerates the localities where stream tin has been worked, and quoted extracts from Tremenheere's reports. The causes retarding the development of the industry are discussed.

1856. Oldham (**1326**—13, 39). Gives details of the ore beds at several localities in Mergui, and describes the methods of working the deposits.

1859. Helfer (**808**—7, 228). A resumé of his observations in Tenasserim.

1872. Fryar (**625**—4). A report on prospecting operations.

The ore is found in layers of gravelly clay ranging up to 8 or 12 ft. in thickness, usually covered by a variable depth of barren soil or rainwash, which must be removed in order to work the deposits. A system of ground sluicing is practised by the Chinese, but some ore is also obtained by panning the sands in the river beds. The greater proportion of the ore is smelted on the spot, the remainder being exported to the Straits Settlements in the form of 70 per cent. concentrates. The furnace in use is of Chinese design, and as described by Butler (**250**, 28) is barrel-shaped, built of sun-dried bricks bound with iron hoops, and about 5 ft. in height. It is fired with charcoal, the blast being furnished by cylindrical bellows, fitted with a piston worked by hand. The tin is refined by passing it through the furnace two or three times, and is cast into ingots of 34 or 74 lb. in weight.

During the years 1888 to 1892, a systematic exploration of the tin-bearing deposits in the Mergui and Tavoy districts was carried out by a party of prospectors under the superintendence of T. W. H. Hughes, the results of which were published in two reports (**888**—30; —33). The first of these gives detailed particulars of each deposit examined, the nature of the country, and the conditions of labour; while the second deals mainly with proposals for the administration of the fields. Reports drawn up by Messrs. Ross Clunis and Primrose, the prospectors attached to the party, are given in appendices. The opinion was expressed that the deposits generally are sufficiently large and accessible to prove remunerative under economical management, and that as the country is opened up, payable deposits would be found to the north and east of the area examined.

A further investigation of the deposits in Lower Burma was undertaken by J. J. A. Page during the years 1907 to 1912. The complete results of his work have not been published, but abstracts of his reports for the first two seasons have been compiled by Holland (**859**—66, 38; —71, 57). The particulars noted below are

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mainly taken from these abstracts and from the reports submitted by Hughes.

Karenni.—KEH-DAUNG or 'Tin-hill' (18° 49′ : 97° 10′). The existence of tin ore in the Bawlake sub-State in Karenni has long been known, but until recently O'Riley (**1340**—10, 444) appears to have been the only European to visit the locality. The mines are situated near MAWCHI, on the northern bank of the Ke-ma-Pyu R. The ore is said to occur in irregular lodes in quartz veins traversing slates, and was smelted on the spot in small furnaces, which were simply holes cut out of banks of clay. Limestone was used as a flux.

In 1910 the mines were visited by Page (*see* Hayden, **793**—24, 75), who reports that the rocks consist of stanniferous granite pierced by quartz veins carrying wolfram and cassiterite. In the Keh-daung area the quartz veins appear to be especially prominent.

Statistics of the production of tin ore in Karenni are available only for the four years 1912 to 1915. During this period the output increased from 1,202 to 6,614 cwt.

Mergui.—Cassiterite is widely distributed through the district and occurs, according to Page, under the following conditions :—

(1) As a constituent of decomposed pegmatite rich in tourmaline and muscovite, known locally as *Kra*.

(2) In massive quartz segregations on the outskirts of granitic hills.

(3) In quartz veins and stringers adjacent to decomposing pegmatite.

(4) In talus accumulations resulting from the disintegration of the foregoing classes, and in gravel deposits along the course of the streams.

Deposits have been noted at the following localities :—

BANHUNI (10° 44′ : 98° 45′). Seven mines in 1889. Ore bed 6 to 8 ft. thick. Water plentiful. According to Hughes (**888**—30, 196), these are the richest mines in the district.

BOKPYIN (11° 14′ : 98° 50′)—YAUNGWA (11° 8′ : 98° 52′). Fifteen native workings in 1907, four of which were leased to Messrs. Kinloch and Eglington. Ore bed at Bokpyin varies between 5 and 6 ft. in thickness, overlaid by 10 ft. of barren soil (**B.** 320).

CH'HANDO (KYANDO), near PALAUK (13° 16′ : 98° 44′). A sample of 'half dressed' tin concentrates from this locality is said by Ross (**1516**) to have yielded 47 per cent. of metal. Fryar (**625**—4, 43) has reported the existence of an abundance of stream tin on feeders of the Palauk R., about 18 miles above the village (**B.** 318).

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HANGPRU (11° 1′ : 98° 50′). Three workings in 1907.

HESAMKONG (11° 31′ : 99° 12′) and KEH KYAUNG, on the Klong Manoron. Eighteen apparently profitable workings in 1907. Work is carried on only during the rainy season. Quartz stringers with cassiterite occur in one of the workings.

KAHAN HILL (12° 20′ : 98° 50′). Tremenheere (**1802**—4, 841) supposed that the tin ore found here occurs *in situ* in a vein of decomposed granite, and considered the deposit to be very rich. Prospecting operations carried out by Fryar showed that the bed in which the tin occurs is of a detrital character, and that the quantity available would not be remunerative (**B.** 319).

KARATHURI (10° 56′ : 98° 48′). Twenty-two workings on the hill sides and low ground in 1907. Ore bed 8 to 12 ft. thick, according to Hughes (**888**—30, 199), of good paying character. Water fairly abundant (**B.** 320).

KYAUNG-KAPRA (10° 55′ : 98° 48′). Five workings in 1907, in alluvium.

KYAUNG-TA-NAUNG (10° 53′ : 98° 47′). Two workings in 1907, in alluvium. The ore bed, according to Hughes (**888**—30, 200), is not more than 3 ft. thick, and is said to be poor in quality. In Fryar's time the outturn is said to have been from 4 to 5 tons of metallic tin annually (**B.** 321).

LENYA (11° 28′ : 99° 2′). Ore bed about 4 ft. thick, beneath 2 ft. to 2 ft. 6 ins. of barren soil.

MALIWUN (10° 14′ : 98° 39′). The tin mines of this area have the widest reputation of any in Mergui, and have more than once been taken up on lease by European firms. According to Oldham (**1326**—13, 40), the annual outturn was from 1,500 to 1,600 ingots of tin, weighing 27 lb. each. The attempt made by Messrs. Strang, Steel & Co. to work the deposits has already been alluded to. From 1894 to 1897 the property was held by the Jelibu Mining and Trading Co., Ltd., whose operations have been described by Parry (**1367**, 26). The amount of ore exported during the three years was 3,407 cwt. Following on prospecting operations carried out by Snow (**1672**) in 1905, a mining lease covering 3 sq. miles was taken out by the Burma Development Syndicate, and is still held by them. The concession includes granite hills containing stanniferous quartz segregations as well as alluvial ground (**B.** 322).

The following deposits in the Maliwun area are enumerated by Page:—

KLONG BANKWA (10° 14′ : 98° 38′). Several small workings by Chinese. The yield of the most profitable working is 6 lb. of cassiterite per cubic yard.

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KLONG NAM SAI (10° 16′ : 98° 39′). One working 42 ft. deep. The ore bed is rich, but lies beneath a great thickness of overburden.

NORTH HILL, PEETOLAI, and KHON MAUNG HILL, held by the Burma Development Syndicate.

HASSEI DENG (10° 9′ : 98° 37′). } Abandoned workings.
KLONG GLAMA (10° 12′ : 98° 39′). }

MAZAW (12° 23′ : 98° 54′). Hughes (**888**—30, 201) remarks that tin ore will probably be found in this area, though no workings were seen.

MERGUI (12° 26¼ : 98° 36′). Low (*Journ. R. As. Soc.*, Vol. III, 47) says that tin ore occurs in the hill on which Mergui is built, and in the streams near the town (**B.** 318).

MIGYAUNG KYAUNG (11° 25′ : 98° 46′). The deposits are said to be rich, but difficult to work through want of water. The ore occurs in pegmatite as well as in alluvium.

SADIEN (11° 23′ : 98° 48′). Many abandoned workings.

TAGU (12° 16′ : 99° 4′), on the Great Tenasserim R. A little tinstone was obtained by Primrose on the slope of a hill about 6 miles to W. by S. of the village (*see* Hughes, **888**—33, 51).

THABALIK (12° 1′ : 99° 16′). According to Hughes (**888**—30, 192), the ore bed is about 8 ft. thick, with an overburden varying from 6 to 10 ft. in thickness. The ore was recovered by a system of ground sluicing, described by Fryar (**625**—4). Prospecting operations carried out by Ross Clunis (*see* Hughes, **888**—33, 48) indicated that the ore is derived from quartz veins traversing slates forming the range separating the Thagyet R., on which Thabalik is situated, from the second branch entering the main river above the mines. Samples of gravel from the river bed yielded 30 per cent. of cassiterite. Five native leases were being worked here in 1907 (**B.** 319).

THARAPÔN (12° 10′ : 98° 55′). Hughes (**888**—30, 189) remarks that the conformation of the ground in this neighbourhood gives a fair chance of meeting with stanniferous deposits. No old workings were seen.

THEINDAW (TENDAÚ, 12° 20′ : 99° 10′). Tremenheere (**1802**—2, 846) considered the deposits here to be rich. Tin ore was obtained by Primrose (*see* Hughes, **888**—33, 52) in fair quantity at several places along the course of the river, also fragments of sandstone containing stanniferous quartz veins. Numerous old workings were seen (**B.** 319).

To-Twé (11° 4′ : 98° 46′). Two workings in 1907. Tin ore occurs in mangrove swamps below tide level.

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YAMÔN (12° 13′ : 98° 47′)—NAUKLÉ (12° 18′ : 98° 47′). Eight shallow workings in 1907. Ore bed 18 ins. to 3 ft. in thickness. The deposits are said to be worth prospecting with a view to dredging.

YE-NGAN (11° 28′ : 98° 48′). Seven workings in 1907, in good alluvium, which might be worked by pond dredging if found sufficiently rich on being tested by borings.

In the Mergui archipelago cassiterite was found by Page (*see* Holland, **859**—71, 56) in gravels on KING'S I. (12° 30′ : 98° 23′), where Fryar considered that a large quantity was available in the bed of the Kitan R.; KISSERING I. (KIT-THA-Y-N, 11° 40′ : 98° 30′); and DAVIES I. (9° 48′ : 98° 4′). Many of the islands of the archipelago are said to be formed of gneissose granite penetrated by intrusive dykes of granite and quartz porphyry, and would be worth prospecting.

The average annual production of block tin in Mergui, during the five years 1909 to 1913, was 1,673 cwt., and of tin ore 1,710 cwt. During 1914 the quantity of block tin produced was 1,963 cwt., and of tin ore 1,861 cwt. In 1915 the corresponding figures were 2,553 and 1,762 cwt. respectively.

Tavoy.—In this district cassiterite occurs under the same conditions as in Mergui, in granite and quartz veins associated with the intrusions. The following localities were examined by Page (*see* Holland, **859**—71, 57) and others:—

HEINDU and HEINDA rivers, flowing into the Great Tenasserim R. near MYITTHA (14° 10′ : 98° 32′). Cassiterite exists within a few feet of the surface in quantities that should be payable. This is probably the area described by Helfer (**808**—5, 30) under the name METAMIO (MYITTHA MYO). He reports that tin-stone is found over an area 60 miles in length by 8 to 12 miles in breadth, and that there were numerous native workings, some of which were carried to a depth of 40 feet (**B.** 317).

HENZAI (HEINZÉ, 14° 45′ : 98° 0′). O'Riley (**1340**—3, 726; —7) states that tin-stone was obtained by washing near the head waters of the streams flowing into the bay of Henzai from the south. Samples of the concentrates contained from 55 to 60 per cent. of tin. He estimated that one man could obtain 18 or 20 lb. a day (**B.** 317).

More recently the tin deposits in this neighbourhood have been described by Foss (**609**). The existence of the ore is said to have been proved to a depth of 15 ft., over an area of about 300 acres.

MAUNGMESHAUNG (14° 9′ : 98° 13′). The tin-bearing gravels in this area are irregular, and will only pay to work at intervals. Stream tin washing is practised on primitive lines. The cassiterite is de-

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rived both from granite and from quartz veins at the junction of the granite with slates.

ONGBINGWIN (14° 37′ : 98° 0′). Cassiterite occurs in quartz veins and in small quartz stringers penetrating sandstones near their junction with granite. The largest vein seen measured 12 ins. in width. The gravels are worked by the natives down to about 6 ft., but the concentrated deposits are said to lie at a depth of about 30 ft. below the present surface.

WAGÔN (14° 11′ : 98° 23′). Old workings were seen along the base of the granite hills near this place, and isolated patches may be found in which the ore is sufficiently concentrated to be worth working.

In addition to these localities, Bleeck (**151**—4, 68) mentions a cassiterite-quartz lode occurring on the KALONTA KYAUNG (14° 19′ : 98° 19′). Two samples of the ore yielded 2·30 and 13·95 per cent. of oxide of tin respectively. Cassiterite is also said to occur with wolfram in lodes at HERMYINGYI (HAMYINGYI, 14° 14′ : 98° 20′).

Previous to the year 1911 the quantity of tin ore produced in Tavoy was very small, not amounting on the average to 30 cwt. annually. In that year, as the result of active prospecting, 802 cwt. of ore were obtained, and during the next two years the production of block tin amounted to 2,572 cwt., and of ore to 51 cwt. Latterly, however, the production has again fallen off, the figures for 1914 and 1915 being 767 and 253 cwt. of ore respectively. Those for 1915 also include 6 cwt. of block tin.

A very large amount of prospecting work was carried on in the Mergui and Tavoy districts between the years 1910 and 1915, but in only one instance was a mining lease applied for. This was granted to the Hindu Chaung Tin Dredging and Mining Co. in 1911, but after a suction dredge had been transported to and erected on the concession, the Company suspended operations in 1913.

Thaton.—Tin-bearing gravels have recently have recently been found in this district, and the prospects are regarded as promising.

TITANIUM *see under* **RARE MINERALS.**

TOURMALINE *see under* **GEM-STONES.**

TRIPLITE *see* **PHOSPHATES—IRON.**

TUNGSTEN.

So recently has tungsten come into general use as an alloy in 'self-hardening' steel, now largely employed in the manufacture of

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high-speed cutting tools, incandescent lamp filaments, etc., that the notices of its occurrence in India are extremely few. In most instances the mineral is casually mentioned as depreciating the value of stream tin deposits, with which it is frequently associated; and it finds no place in the Economic Section of the Manual of the Geology of India, published in 1881. The most important deposits of wolframite are those of Burma, where it is found *in situ* under the same conditions as cassiterite, though not usually associated with it in the same lodes. Its occurrence has also been reported from a few localities in the Indian peninsula. For some years Burma has headed the list of countries that produce wolframite, with an annual output of about 25 per cent. of the world's supply.

BIHAR AND ORISSA.

Singbhum.—Wolfram has recently been found at KALIMATI (22° 46′ : 86° 17′) on the Bengal-Nagpur railway. About 8 tons of mineral were won in the year 1916.

BURMA.

Karenni.—Wolfram was found by Page associated with cassiterite in quartz veins at the tin mines of KEH-DAUNG (*see* TIN). The average annual production during the four years 1910 to 1913 was 54 tons. In 1914 the output rose to 138 tons, and in 1915 to 330 tons.

Mergui.—Tremenheere (**1802**—2, 849) mentions the occurrence of wolfram with stream tin on the LOUNGDOUNGIN stream, which enters the Little Tenasserim R. a few miles to the S. of TENASSERIM (12° 5′ : 99° 3′). In his second report on the tin of Mergui (**1802**—4, 847), wolfram is said to occur in the MALIWUN area (10° 14′ : 98° 39′), and in considerable quantities in the stream tin deposits of YAMÔN (12° 13′ : 98° 47′).

During the five years 1911 to 1915, the average quantity of tungsten ore produced annually in Mergui was 190·5 tons.

Tavoy.—During the course of his investigation of the tin ore deposits of Tavoy, a rich wolframite lode was discovered in 1908 by Page (*see* Holland, **859**—71, 59) on the SANCHI stream, which joins the Pauk Tein (Pauk-taing) R. near PAYAGÉ (14° 6′ : 98° 18′). The lode was 14 ins. wide, and formed one of a series of about 50 nearly vertical quartz reefs varying in width from an inch or two to 30 ins.

In a paper on the occurrence of wolframite in Tavoy, published in 1913 (**154**—4), Bleeck has described the geology of the western portion of the district, and the petrological characters of the rocks

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associated with the lodes. The granites are intrusive in a series of sandstones, shales, and conglomerates of uncertain age, known as the 'Mergui series,' which have been altered into quartzites and schists when in contact with the igneous intrusions. Both the granite and the stratified rocks are traversed by numerous veins of milk-white, opaque quartz, varying from a fraction of an inch to over 12 ft. in width, and often continuous for considerable distances. The mineralisation of the veins is confined to the contact zone, but the distribution of the wolframite is extremely erratic, long stretches of apparently one and the same vein containing no ore. The wolframite occurs in single crystals measuring up to 3 or 4 ins. in length, or in crystalline aggregates which may weigh as much as 90 lb. Tungstic ochre is often associated in small quantities with the wolframite. A typical specimen of the latter mineral contains about 76 per cent. of tungstic trioxide (WO_3).

Lodes carrying wolfram were found at the following localities:—

At the 19th mile on the Tavoy-Wagôn road, about a mile beyond Thingandôn (14° 10′ : 98° 21′).

Byauk Kyaung (14° 20′ : 98° 15′).
Kalonta Kyaung (14° 19′ : 98° 19′).
Pa Kyaung (14° 30′ : 98° 6′).
Thangazôn (14° 11′ : 98° 17′).

One of the lodes observed in the Kalonta area was a greisen composed of granitic quartz and muscovite with wolframite scattered in small crystals throughout the rock.

A sample of ore concentrates from the alluvial deposits contained 61 per cent. of tungstic trioxide.

Following on the discovery of wolframite *in situ* by Page, great activity has been shown in prospecting for this mineral. During the six years 1910 to 1915, the number of prospecting licenses issued in the Tavoy district alone amounted to 419. In this period the production of tungsten ore increased from 362 to 2,033 tons, the average annual output for the five years ending with 1915 being 1,593 tons. In consequence of the cessation of supplies of tungsten and ferro-tungsten from Germany, owing to the war, steps were taken by Government to stimulate the search for the mineral; but these measures have not been reflected in the returns of mineral production yet published (*see* Hayden, *Records, G. S. I.*, Vol. XLVII, p. 24).[1]

[1] Since the above was written, information has come to hand to the effect that the output for the year 1916 was nearly 3,000 tons. The increase is attributed largely to the energetic measures taken by the Local Government to stimulate the output.

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Thaton.—Outputs of 17 and 49½ tons of wolfram were recorded for this district during the years 1914 and 1915 respectively; but no account has yet been given of the localities or mode of occurrence of the mineral.

Yamethin.—Bleeck has reported the occurrence of a well defined lode carrying wolfram near KALAW (20° 38′ : 96° 36′), on the road from Thazi to Taunggyi. Another lode was seen further to the north near NYAUNGYA (21° 7′ 30″ : 96° 20′) in the Yengan sub-State (**861**, 279).

CENTRAL PROVINCES.

Nagpur.—AGARGAON (21° 6′ 30″ : 79° 32′). A discovery of wolframite, made by Mr. Kellerschon in 1907 while prospecting for manganese ore in this district, has been described by Fermor (**577**—26) and Low (**1096**—2). The wolframite is very unevenly distributed through veins and stringers of quartz interbedded with mica and tourmaline schists, being apparently more intimately connected with the latter. About 1½ tons of the mineral were raised during the years 1908 to 1910 from pits and trenches about 8 ft. deep; but no further development appears to have taken place. On analysis the crystals yielded 65·05 per cent. of tungstic trioxide.

MADRAS.

Trichinopoly.—A specimen of wolfram, containing 31·72 per cent. of tungsten and 3·15 per cent. of tin, is reported to have been found by P. N. Bose near KADAVUR (10° 36′ : 78° 15′). Another specimen was found near a pegmatite vein on the eastern flanks of URURARKARAD (**861**, 280).

RAJPUTANA.

Marwar (Jodhpur).—DEGANA (26° 50′ : 74° 24′). Reference to an occurrence of wolfram in a hill near Degana railway station was made by Hayden (**793**—31, 26) in 1913, and further information on the discovery has been given in his General Report for 1915 (*Records, G. S. I.*, Vol. XLVII, p. 26). Three small hills consisting chiefly of granite are penetrated by nearly vertical quartz veins containing coarsely crystallised mica and wolfram. The veins are usually thin, but in one place a mass of quartz measuring 20 by 20 feet was seen, containing considerable quantities of wolfram. At present the depth to which the lodes extend is unknown. The deposits were being worked by open quarries, and the output was said to be about 1½ cwt. a day.

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URANIUM *see* **RARE MINERALS—PITCHBLENDE** *and* **SAMARSKITE.**

VANADIUM *see under* **RARE MINERALS.**

VIVIANITE *see* **PHOSPHATES—IRON.**

WATER *see* **MINERAL WATERS.**

WOLFRAM *see* **TUNGSTEN.**

YTTRIUM *see* **RARE MINERALS—GADOLINITE** *and* **SAMARSKITE.**

ZINC.

In a paper read before the Royal Geological Society of Ireland in 1886, Ball (**71**—63) gave an account of the occurrence of the ores of zinc in India, containing references to the ancient and modern literature of the subject, and to the trade in this metal with China. The paper concludes with a glossary of the oriental and other titles used for zinc and its alloys.

Zinc blende is occasionally mentioned as accompanying the ores of lead and copper, but in very few instances does it occur in sufficient quantity to be commercially valuable.

AFGHANISTAN.

Lord (**1091**—2, 536) says that in the GHORBAND VALLEY (34° 57′ : 68° 52′) white sulphate of zinc, locally known as *zak*, occurs as an efflorescence on the surface of volcanic ash beds. No mention is made of its employment for any purpose (**B.** 313).

BURMA.

Shan States (N.).—The silver lead ores of BAWDWIN (23° 7′ : 97° 20′ 30″) contain an appreciable proportion of zinc blende. It occurs occasionally, according to Coggin Brown (**1035,** 255), in massive bands of a blackish brown colour, but more commonly in microscopic crystals intimately associated with the galena. In three of the ore bodies that have been opened up, the percentage of zinc amounts to 16, 14·2, and 29·8 respectively (**862,** 129).

This is the only locality within the Indian Empire that now produces zinc ore. During 1913 the Burma Corporation extracted 3,871 tons of zinc ores, and in the following year 8,553 tons, which were shipped to Belgium and Germany for reduction. In

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1915 the amount exported was only 196 tons. The question of erecting works in the country, not only for smelting the ores, but also for the production of sulphuric acid as a bye-product, is under consideration.

Tavoy.—Mason (**1185**—1, 48) says that in a broken boulder brought to him at Tavoy there was a vein of ore which he judged to be zinc blende. He was unable to ascertain the locality from which it came. An ore of zinc is also said to have been found by Helfer on one of the islands in the Mergui archipelago (**B.** 313).

MADRAS.

Kurnool.—Mallet (**1159**—25; —29) has described specimens of ferruginous smithsonite,—carbonate of zinc,—associated with barytes, green blende, and galena, which there is reason to suppose were brought from the deserted lead mines at BASWAPUR (BASAVAPURAM, 15° 24′ 30″ : 78° 41′ 30″). He remarks that the mineral probably escaped recognition by the native miners on account of its non-metallic appearance (**B.** 312).

PUNJAB.

Kangra.—Zinc blende is mentioned by Mallet (**1159**—1, 166) as sparingly disseminated through the gangue of the antimony ore at the SHIGRI GLACIER (32° 17′ : 77° 40′).

RAJPUTANA.

Marwar (Jodhpur).—Walter (**1879**, 3) states that zinc ore was formerly obtained in small quantities near the town of SOJAT (25° 56′ : 73° 43′).

Mewar (Udaipur).—JAWAR or ZAWAR (24° 21′ : 73° 45′). The zinc mines at this locality appear to have been of considerable importance. Tod, in his Annals of Rajast'han (**1788**—1, Vol. I, 504), mentions them incidentally as producing tin, and says that the revenue derived from them exceeded £20,000 annually. They were closed at the time of the great famine in Western India of 1812-13. According to Brooke (**203**—1), the ore is said to occur in veins 3 or 4 ins. thick, and sometimes in bunches, in quartz rock. The pure ore, being very friable, was pounded and freed from gangue, and smelted in bottle-shaped crucibles 3 ins. in diameter, with necks

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6 ins. long. These were placed in the furnace in an inverted position, the metal being sublimed in the necks. Any admixture of quartz with the ore is said to have caused the crucibles to crack. Another account by an anonymous contributor to the *Indian Antiquary* (**35**—88) deals mainly with the surroundings of the mines, which are said to be very extensive, but were apparently worked in the usual unsystematic Indian manner. The locality has not been described by a geologist, but the ore is believed to be smithsonite, and to occur in quartzites of the Arvali series (**B.** 312).

SIKKIM.

Zinc ore in the form of calamine or smithsonite is found associated with some of the copper ores of Sikkim, and blende is commonly found in the lodes containing pyrites and pyrrhotite (**862**, 127, 261).

UNITED PROVINCES.

Dehra Dun (Jaunsar).—In one of the lead mines on the Tons R., about 25 miles above KALSI (30° 32′: 77° 54′), Medlicott (**1197**—5, 179) noted a stringer of mixed ore associated with the galena, though keeping rather distinct from it, consisting principally of zinc blende with some galena, iron pyrites, and quartz (**B.** 313).

ZIRCON *see under* **GEM-STONES.**

CALCUTTA : PRINTED BY SUPDT. GOVT. PRINTING, INDIA, 8, HASTINGS STREET.

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INDIAN GEOLOGY, PART II

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Compiled by T. H. D. LaTouche, M.A., F.G.S.
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Published by order of the Government of India.

CALCUTTA:
SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY OF INDIA,
27, CHOWRINGHEE ROAD.

1921

Price One Rupee.

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INDEX OF LOCALITIES.

On the degree sheets now being issued by the Survey of India, referred to in this index, the corrected values of the co-ordinates of longitude are given, as compared with those in the 'Atlas of India,' which is now out of print.

A correction of—3′ 36″ should therefore be applied to the co-ordinates of longitude inserted in the "Notes on Economic Minerals," in order that they may correspond with those shown on the degree sheets.

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Dasht-i Safed, sulphur	33 M/15	470
Dherband, copper	— —	114
Dobandi valley, copper	38 G/5	114
Farangal, silver-lead	38 A/12	291
Fuligird (Faragard), antimony	38 B/13	10
Ghazni, gypsum	38 C/6	225
Ghorband, zinc	38 A/12	488
Gurmsael (Garmsir), salt	30 N/2	434
Hajigak pass, iron	38 B/2	235
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Landi Kotal, alum	38 N/4	4
Lughman, gold	38 J	189
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Peshat, gold	38 N/2	189
Pir Kisri, mercury	30 K/12	363
Saighan, gypsum	33 M	225
Shah Maksud range, copper	34 E/5*	114
„ „ „ lead	„	291
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Sukht-i-Chenar, iron	——	235
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Tor Sappar, graphite	38 N/4	219
Ursuk, lead	38 C/14	291
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Balni creek, manganese	86 C/16	319
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Homfray's Ghat, serpentine	87 A/10	28
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Rang-u-Chang, copper	87 A/10	114
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South Corbyn, limestone	87 A/10	28
Viper I., lignite	87 A/10	306
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Dirjmu R., lignite	83 L/13	306
Geku, iron	82 P/3	236
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Sisi R., copper	82 L/13	114
Aka Hills—		
Borholi R., coal	83 A/12	67

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Bor Kamti, copper	——	114
„ silver-lead	——	291
Cachar, salt	..	434
Badarpur, petroleum	83 D/9	399
Kopili R., mineral water	83 C/10	373
Larang R., petroleum	83 C/12	399
Masimpur „	83 D/13	399
Saraspur hills „	83 D/10	399
Siltek (Shialtek) „	83 D/9	399
Daphla Hills—		
Dikrang R., coal	83 E/12	67
Darrang—		
Barapani (?Borholi) R., gold	83 B/13	191
Buragaon (Bargang) R., „	83 F/1	191
Garo Hills—		
Daranggiri, coal	78 K/14	68
Domalgiri, kaolin	78 K/2	284
Harigaon, coal	78 K/2	68
Mahendraganj, kaolin	78 G/15	284
Pundengru, coal	78 K/15	68
Rongrenggiri, „	78 K/10	68
Siju „	78 K/11	68
Tura, kaolin	78 K/2	284
Khasi & Jaintia Hills—		
Borsora, coal	78 O/4	70
Chela, petroleum	78 O/12	399
Cherra Punji, coal	78 O/11	68

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Khasi & Jaintia Hills—*contd.*		
Cherra Punji, iron	78 O/11	236
„ „ limestone	„	28
„ „ sandstone	„	29
Dedum hill, coal	„	69
Dhamalia R., petroleum	78 O/8	399
Dona R., „	83 C/8	399
Dongchala, coal	83 C/7	70
Jarain „	83 C/3	69
Jawai, fire-clay	83 C/3	146
Khasimara, petroleum	78 O/12	399
Lairangao, coal	78 O/11	69
Lakadong „	83 C/8	69
Langrin „	78 O/4	70
Mao-be-larkar, coal	78 O/15	69
Maophlang „	78 O/15	69
Maosandram „	78 O/11	69
Molim, iron	78 O/15	236
Nokhara, coal	83 C/7	69
Nongmaweit, corundum	78 O/2	138
Nongryniew (Noringyao) gold	78 O/2	138
Nongspong, iron	78 O/11	236
Patarknang, corundum	78 O/2	138
Riandu R., „	78 O/2	138
Satunga, coal	83 C/7	69
Surarim, iron	78 O/11	236
Than-ji-nath, coal	78 O/15	70

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ASSAM—*contd.*		
Khasi & Jaintia Hills—*contd.*		
Umblay R., coal	78 O/4	70
Um Plu „	87 O/3	70
Um Rileng „	78 O/14	70
Umsaomat „	78 O/11	69
Wapung „	83 C/7	70
Lakhimpur—		
Bappa Pung, petroleum	83 M/11	400
Borhat, coal	83 M/8	70
„ petroleum	„	401
„ salt	„	434
Buri Dihing R., gold	83 M/15	191
Dekhia Juli, petroleum	83 M/7	400
Derpai R., gold	83 I/6	192
Dibong R., „	82 P/16	191
Digaru Mukh, gold	92 A/1	191
Digboi, petroleum	83 M/11	400
Dihang R., gold	83 M/9	191
„ „ limestone	„	29
Dikrang R., gold	83 E/16	191
Disang R., coal	83 M/8	71
„ „ petroleum	„	401
Dora R., kaolin	92 A/5	283
Guri Mara, gold	83 M/13	191
Hapjan, petroleum	83 M/8	401
Hilika „	83 M/11	401
Hone Jan, gold	83 M/11	191

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ASSAM—*contd.*		
Lakhimpur—*contd.*		
Jaipur, coal	83 M/7	70
„ iron	„	236
Janglu (Joglo) Pani, gold	83 M/11	191
Lohit-Brahmaputra „	83 M/13	191
Makum, alum shale	83 M/11	4
„ coal	„	71
„ fire-clay	„	146
„ petroleum	„	401
„ pyrites	„	470
Nahor Pung, petroleum	83 M/8	401
Namchik (Namrup) R., coal	92 A/3	72
„ „ „ petroleum	92 A/3	401
Namdang R., coal	83 M/11	71
Nizamghat, gold	82 P/16	191
Noa Dihing R., gold	83 M/15	192
„ „ „ platinum	„	426
Parghat, gold	92 A/1	192
Pasighat, „	82 P/8	191
„ lignite	„	306
Sadiya, salt	83 M/9	434
Sial Ghar, petroleum	83 M/7	400
Sibia Mukh, gold	83 M/9	191
Sisi R., „	83 I/10	192
Subansiri R., „	83 I/6	192
Supkong, petroleum	83 M/15	402
Tenga Pani, gold	92 A/1	192

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Lakhimpur—*contd.*		
Tirap R., coal	83 M/15	71
Manipur, copper	...	114
„ fullers' earth	...	150
„ iron	...	237
Naga Hills, salt	...	434
Tepe R., slate	83/K	29
Tuzu R., „	83/K	29
Nowgong—		
Gudu, petroleum	83 G/5	402
Jangthang, salt	——	435
Longloi hill, coal	83 G/1	72
Meyongdisa R., petroleum	83 G/5	402
Sibsagar—		
Bor Pathar, kaolin	83 F/15	284
Chingan, petroleum	83 J/13	402
Deopani R., limestone	83 F/16	29
Dhansiri R., gold	83 F/15	192
„ „ kaolin	„	284
Dikhu R., coal	83 J/13	73
„ „ vivianite	„	423
Disai R., coal	83 J/6	72
„ „ gold	„	192
Doigrung R., coal	83 F/15	72
„ „ limestone	„	29
Golaghat, iron	83 F/14	236

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ASSAM—*contd.*		
Sibsagar—*contd.*		
Gota Jan, gold	83 J/6	192
Haria Jan, limestone	83 F/16	29
Hattigar, iron	——	236
Jamuna R., coal	83 G/5	72
„ „ limestone	„	29
Janji R., coal	83 J/10	72
„ „ gold	„	192
Japu, coal	83 J/6	72
Kanugaon, petroleum	83 M/4	402
Mikir hills, iron	83 F	237
Nambor R., coal	83 F/15	72
„ „ kaolin	„	284
„ „ limestone	„	29
„ „ mineral water	„	378
Nazira, coal	83 J/13	73
„ peat	„	396
Pangso, limestone	83 F/15	29
Saffrai R., coal	83 J/13	73
Tel Pung, petroleum	83 J/13	402
Tiru R., coal	83 J/13	73
Tirugaon, iron	83 J/13	236
Singpho Hills—		
Maiobum, coal	92 A/7	73
„ petroleum	„	402
Nchongbum „	92 A/10	402

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Draj Bent, sulphur	——	470
Gokurth „	34 O/6	470
Kirta, mineral water	34 O/6	373
„ petroleum	„	403
Mach, coal	34 O/5	73
Sor range, coal	34 O/5	73
Jhalawan, gypsum	——	225
Bania Pani, magnesite	35 I/7	312
Kil Chotok, sulphate of iron	35 I/9	466
Ladon pass „ „	35 I/9	466
Pab hills, manganese	35 J	319
Shekran, antimony	35 I/5	10
„ lead	„	291
„ manganese	„	319
Kachhi—		
Lakha, mineral water	34 P/8	373
Pulej, gypsum	39 C/8	225
Sanni, alunogen	34 O/12	8
„ petroleum	„	403
„ sulphur	„	471
Shahpur, gypsum	39 D/6	225
Uch, gypsum	39 D/10	225
„ mineral water	„	374
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Koh-i Sultan, sulphate of iron	30 K/12	466
„ „ sulphur	„	470

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Saindak, ,,	30 G/11	115
,, lead	,,	291
Las Bela—		
Aghor, petroleum	35 G/7	403
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,, ,, sulphur	,,	471
Pabni Chauki, barytes	35 K/15	18
Ras Kachari, petroleum	35 G/15	403
Sarmowli R., barytes	——	8
Shah Bellawl, copper	35 O/1	115
Mekran, gypsum	..	225
Golkurt, sulphur	35 C/3	471
Gwadur, petroleum	31 K/8	403
Quetta-Pishin, limestone	..	29
Ghaziaband pass, gypsum	34 J/15	225
Khanozai, chromite	34 N/6	63
Kil' Abdulla, antimony	34 J/10	11
Kojak Amran range, copper	34 J	115
Pishin valley, salt	34 K/2	435
Sarawan, gypsum	..	225
Johan, coal	34 K/15	74
,, copper	,,	115
Zarakhu R., coal	34 N/4	74
Ziarat, copper	34 K/15	115

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Chamarlang, coal	39 F/8	74
Duki „	39 B/12	74
Harnai, „	34 N/16	74
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Khattan, gypsum	39 C/6	226
„ mineral water	„	373
„ petroleum	„	404
„ sulphur	„	471
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Spintangi, gypsum	39 C/1	226
„ mineral water	„	373
Zhob, chromite	..	63
„ sulphate of iron	..	466
BARREN ISLAND, sulphur	86 H/15	471
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Ballia-Narainpur, iron	72 P/12	237
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Tantipara, mineral water	73 M/5	374
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Barakar, coal	73 I/14	79
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„ manganese	„	320
„ sandstone	„	30
Barul (Badul), iron	73 M/2	238
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Mallapur, fireclay	——	146
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„ phosphate of lime	„	424
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,, ,, copper	,,	117
Sikbhar, iron	78 A/12	240
Sivok (Chawa) R., lignite	78 B/5	306
Sukkam R., kaolin	——	284
Tindharia, coal	78 B/5	75
Yongri hill, copper	78 B/9	117
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Baxa, copper	78 F/9	117
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„ „ sulphate of magnesia	..	467
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Jamalpur, vivianite	79 B/10	423
Sealdah, peat	79 B/6	396
Silver Tree G. T. S., manganese	79 C/1	319
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Balla, steatite	78 F/5	457
Chamurchi, copper	78 F/1	117
Kala Pani, coal	78 N/13	76
Kangra Chu, gypsum	78 N/1	226
Paro, iron	78 E/7	240
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Balasore, salt—	..	435
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Dudijor, silver-lead	72 L/10	292
Gauripur (Phaga), silver-lead	72 L/13	292
Gonora, lead	72 L/10	292
Karda „	72 L/10	292

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Katauria, iron	72 L/10	240
Kejuria, silver-lead	72 L/10	292
Khardeh hill, kaolin	72 O/7	284
Kharikhar, silver-lead	72 L/13	292
Patarghatta hill, fire-clay	72 O/3	146
„ „ fullers' earth	„	150
„ „ kaolin	„	284
Bonai—		
Bonaigarh, gold	73 C/13	194
Durjing „	73 C/13	194
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Killah Mootree, sandstone	73 H/11	31
Kukker (Kakari), kaolin	73 H/14	285
Mahanadi R., garnet	73 H	170
Naraj, kaolin	73 H/15	285
Nilgiri hills, corundum	73 K	139
„ „ potstone	73 K	457
Gangpur—		
Bisra, limestone	73 F/4	31
Gariajhor, manganese	73 B/4	319
Giringkela, gold	64 N/16	194
Ib R., „	73 B/4	194
Rourkela, limestone	73 B/16	31

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Brahmjuni hill, potstone	72 H/1	457
Dabur, mica	72 H/10	365
Gaya, ochre	72 H/1	392
Hangriyo (Hanreea), alum	72 H/5	4
Nawada, soda	72 H/9	453
Rajauli, mica	72 H/10	365
Singar, columbite & tantalite	72 H/6	429
„ pitchblende	„	431
„ triplite	„	424
Hazaribagh, molybdenum	72 H/6	389
Ballia, coal	73 E/5	77
Baragunda, copper	72 L/4	117
„ lead	„	292
Barhamasia, „	72 L/7	292
Belkapi (Suraj Khund), mineral water	72 H/12	375
Bendi, mica	72 H/6	365
Bokaro R., coal	73 E/9	76
„ „ sandstone	„	31
Chappatand, tin	72 H/14	476
Charki, mica	72 H/14	365
Chopé, coal	72 H/4	76
Dabur, arsenic	72 H/14	14
Dhab arsenic	72 H/14	14
„ mica	„	365
Doari, mineral water	72 H/4	375
Domchanch, mica	72 H/11	365

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BIHAR & ORISSA—*contd.*		
Hazaribagh—*contd.*		
Gawan mica	72 H/14	365
Gharanji „	72 L/2	365
Giridih, apatite	72 L/8	424
„ coal	„	76
Gondalpur, coal	73 E/5	78
Gulgo, copper	72 L/7	118
„ lead	„	293
Hazaribagh, garnet	73 E/5	170
„ iron	„	240
Hisatu, antimony	73 E/1	11
„ lead	„	293
Indra-Jurba, mineral water	73 E/5	375
Itkhuri, coal	72 H/3	77
Karanpura, coal	73 E/5	77
„ iron	„	240
Karharbari, coal	72 L/8	76
„ iron	„	241
Katkamsandi, manganese	72 H/4	320
„ mineral water	„	375
Kesodih, mineral water	72 L/4	375
Khesmi, lead	72 L/7	292
Kodarma, apatite	72 H/11	424
„ columbite	„	429
„ mica	„	365
Kowa Gandwani, mineral water	73 E/6	375
Lurgutha, mineral water	——	375

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BIHAR & ORISSA—*contd.*		
Hazaribagh—*contd.*		
Mehandadi, lead	72 L/7	292
Nauwadih „	72 L/7	292
Nurunga (Nurgo), tin	72 L/4	476
Nyatand, lead	72 H/10	293
Parseya „	72 H/16	293
Pihira, tin	72 H/14	477
Pindarkun, mineral water	72 H/4	375
Ramgarh, coal	73 E/10	78
„ iron	„	241
Simratari, tin	72 H/14	477
Sirsia, manganese	72 L/3	320
Sosonia, mineral water	——	375
Tendwa, iron	73 E/1	241
Tendwaha R., beryl	72 H/14	156
Tisri, mica	72 L/2	366
Tutki Ghat, corundum	73 E/9	138
Kalahandi—		
Bondesor, diamond	65 M/1	159
Densurgi, graphite	64 P/8	219
Kasipur, marble	65 M/3	31
Koladi Ghat, graphite	65 M/5	219
Korlapat hill, bauxite	65 M/2	20
Olatura, cobalt	64 P/11	112
„ iron	„	241
„ manganese	„	320
Keonjhar, potstone	..	457

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Manbhum, kaolin	..	285
„ slate	..	31
Ambikanagar, iron	73 J/13	241
Baghmara, limestone	73 I/14	31
Bamni R., gold	——	194
Bauch, iron	73 J/9	241
Beldi, silver-lead	73 J/5	293
Dekia „ „	73 J/9	293
Dhobni, gold	73 L/8	194
Ghagra, lead	73 J/9	293
Guram R., platinum	73 J/5	426
Hansipathar, limestone	73 I/10	31
Jhanjijhore, lead	73 J	293
Jharia, coal	73 I/6	78
Kalianpur, copper	73 I/4	118
Karkari R., gold	73 E/16	194
Katrah, iron	73 J/13	241
Kowari R., gold	73 I/8	194
Kushboni, lead	73 J	293
Lataparah „	73 J	293
Lewshai „	73 J	293
Manbazaar, ilmenite	73 I/12	431
„ iron	„	241
Moisara, potstone	73 E/16	457
Mutgoda „	73 J/13	457
Nannah, lead	73 J/9	293
Parada, „	73 J/9	293

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BIHAR & ORISSA—*contd.*		
Manbhum—*contd.*		
Patkum, gold	73 E/16	194
Purda, copper	73 J/9	118
Salbanni, corundum	73 I/8	138
„ kyanite	„	174
„ rutile	„	432
Sheopur (Sarsa), mineral water	73 I/10	375
Subarnarikha R., gold	73 J	194
Supur, ilmenite	73 I/16	432
Tatlui (Tantolya), mineral water	73 I/10	376
Telaia, iron	73 I/1	241
Teludi „	73 I/14	241
Tutko R., gold	73 J/9	194
Mayurbhanj, ochre	..	392
Badampahar, iron	73 J/4	242
Bangarposi, mica	73 J/12	366
Baripada, pottery clay	73 K/9	285
Borai R., gold	73 J/3	194
Godia R., „	73 J/7	194
Gohadongri, gold	73 J/7	194
Gurguria, potstone	73 K/5	458
Gurumaishini, iron	73 J/7	242
Jamgodia, mica	73 J/12	366
Kuliana, manganese	73 J/12	320
Kudersai, gold	73 J/3	194
Malamghatti pass, pyrites	73 J/3	472
Nulungi, potstone	73 K/9	458

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	Sheet.	Page.
BIHAR & ORISSA—*contd.*		
Mayurbhanj—*contd.*		
Okampad, iron	73 J/8	242
Raibedi, mica	73 J/3	366
Rangom hill, asbestos	73 J/3	15
Ruasi, gold	73 J/7	194
Sankrai R., mica	73 J/12	366
Sapgora, gold	73 J/3	194
Sirsa, mica	73 J/12	366
Tiring (? Tiringdih), mica	73 J/2	366
„ potstone	„	458
Monghyr—		
Bhimband, mineral water	72 K/8	376
Bhurka „ „	72 K/11	376
Goria Koh Ghat, asbestos	72 K/8	16
Jamalpur, slate	72 K/7	32
Jamui, corundum	72 L/1	138
Janam Khund (Bharari) mineral water	72 K/8	376
Katnowa hills, manganese	72 L/5	320
Kharakpur hills, silver-lead	72 K	293
„ „ slate	„	32
Lachmi Khund, mineral water	72 K/8	376
Laheta, hornblende-schist	——	32
Mahaisri, mica	72 L/6	366
Nawadih (Jha-Jha), mica	72 L/5	366
Pananoa hill, columbite & tantalite	72 L/5	430
Panchbhar, mineral water	72 K/8	376
Pirpahari hill, asbestos	72 K/11	16

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	Sheet.	Page.
BIHAR & ORISSA—*contd.*		
Monghyr—*contd.*		
Rameswar Khund, mineral water	72 K/8	376
Rishi Khund „ „	72 K/8	376
Shekhpura, soda	72 G/16	453
Singhi Rikh Tatal Pani, mineral water	72 K/4	376
Sita Khund, mineral water	72 K/11	376
Palamau—		
Aurunga R., coal	73 A/5	82
Balumath, iron	73 A/13	244
Balunagar „	73 A/9	244
Barikhap, lead	73 A/13	293
Daltonganj, coal	72 D/4	82
„ copper	„	118
Deredag, limestone	73 A/9	32
Ghorasan R., coal	73 A/1	83
Hutar. „	73 A/1	83
Jarum, mineral water	73 A/9	376
Jinjoi R., coal	72 D/4	82
Kokraha (Thatha), mineral water	73 A/1	377
Maila R., limestone	73 A/5	32
Morwai, iron	73 A/1	244
Nawadih „	73 A/1	244
Neturhat, bauxite	73 A/7	20
„ iron	„	244
Olherpat (Oieypat), limestone	73 A/9	32
Pandua, coal	72 D/4	82
Rajbar, iron	73 A/9	244

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	Sheet.	Page
BIHAR & ORISSA—*contd.*		
Palamau—*contd.*		
Rajhara, coal	72 D/4	82
Simah, diamond	73 A/6	159
Singra, coal	72 D/4	82
Pal Lahara, iron	73 G/3	243
Patna—		
Rajghir, mineral water	72 G/8	377
Tapoban „ „	72 G/8	377
Puri—		
Atari, mineral water	73 H/12	375
Chilka lake, monazite	74 E	390
„ salt	„	435
Khurda, kaolin	73 H/12	285
Ranchi—		
Sankh R., diamond	73 A/3	159
Sili, lead	73 E/15	294
Sambalpur, laterite	..	32
Amdiah, iron	64 O/15	244
Hira Khund, diamond	64 O/14	160
Ib R., gold	64 O/14	195
Jhuman (Jumari), silver-lead	64 O/14	294
Kujerma, limestone	73 C/1	32
Kutarbaga, iron	73 C/2	244
Mahanadi R., diamond	64 O/14	160
„ „ gold	„	195
Sambalpur, gold	64 O/15	195
Tahud „	64 O/14	195

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	Sheet.	Page.
BIHAR & ORISSA—*contd.*		
Sambalpur—*contd.*		
Talpuchia, lead	73 C/1	294
(Patna)—		
Bijkomar, rock crystal	64 P/6	176
Bolangir, limestone	64 P/6	32
Daramgarh, graphite	64 P/3	220
Domaipali „	64 P/1	220
Marna „	64 P/2	220
Santal Parganas—		
Akasi (Panch Pahar), lead	72 P/2	294
Asurni, calcareous tufa	——	33
Bagmara, kaolin	72 P/6	286
Bairuki, copper	72 L/10	118
„ silver-lead	„	294
Baramasia, mineral water	72 P/10	377
Bargo, fire-clay	72 P/6	146
Bhukhanda, kaolin	72 P/7	286
Bhulgora, fire-clay	72 P/5	147
Bhumka, mineral water	72 P/8	377
Bindrabun, calcareous tufa	72 O/12	33
Bodh Bandh, copper	72 L/16	118
Bora Ghat, fire-clay	72 O/8	147
Brahmini R., coal	72 P/11	83
Burari, fire-clay	72 P/5	147
Burhait, agate	72 P/9	152
„ amethyst	„	155

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	Sheet.	Page.
BIHAR & ORISSA—*contd.*		
Santal Parganas—*contd.*		
Burio, flag-stone	72 O/12	33
Chaparbhita, coal	72 P/5	84
Chilgo, fire-clay	72 P/6	147
Dhumabhita „	72 P/6	147
Dhumni „	72 P/5	147
Dodhani, kaolin	72 P/7	286
Dubrajpur, coal	72 P/7	84
Ganges R., glass-making sand	72 O/16	186
Gilhurria, coal	72 P/5	84
„ fire-clay	„	147
Gugri, fire-clay	72 P/6	147
Hura, coal	72 P/5	84
„ fire-clay	„	147
„ kaolin	„	286
Jainti, coal	72 L/12	84
Jharya (Jherwa) Pani, mineral water	72 P/7	377
Jiajore, fire-clay	72 P/5	147
Karanpur, kaolin	72 P/7	286
Katangi „	72 P/7	286
Khari Pahar, kaolin	——	285
„ „ ochre	——	392
Khijaria, fire-clay	72 P/8	147
Kundit Karaia, coal	73 M/1	84
Lau-lau-dah (Sibpur), mineral water	72 P/11	377
Lohandia, fire-clay	72 O/8	147
„ kaolin	„	285

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	Sheet.	Page.
BIHAR & ORISSA—*contd.*		
Santal Parganas—*contd.*		
Mangal Hat, glass-making sand	72 O/16	186
,, ,, kaolin	,,	286
Mohwagarhi, calcareous tufa	72 P/7	33
Narganjo, fire-clay	72 P/7	147
Nunbil, mineral water	72 P/4	377
Pachwara, coal	72 P/6	84
Piaram, kaolin	72 O/8	286
Pir Pahar, glass-making sand	72 O/16	186
Rajabhita, calcareous tufa	72 P/6	33
,, kaolin	,,	286
Rajmahal hills, basalt	72 P	33
,, ,, iron	,,	244
,, ,, sandstone	,,	33
Rohri, fire-clay	72 P/5	147
Sahajori, coal	72 L/16	84
Salduha, fire-clay	72 P/11	147
Sankera hills, lead	72 P/7	294
Simlong, fire-clay	72 P/6	147
Simru ,, ,,	72 O/8	147
Surwa ,, ,,	72 P/7	147
Susumpani, mineral water	72 P/8	377
Tapatpani ,, ,,	72 P/8	377
Tat-loi (Tapnai), mineral water	72 P/3	377
Telbhita, fire-clay	72 P/5	147
Turi (Tiur) Pahar, lead	72 L/15	294
Umbapani, fire-clay	72 P/11	147

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	Sheet.	Page.
BIHAR & ORISSA—*contd.*		
Shahabad—		
Chuthan, ochre	63 P/10	393
Durguti R., alum	63 P/10	4
Kaimur range, sandstone	——	33
Mandpa, ochre	63 P/10	393
Margohi, limestone	72 D/1	33
Phulmaria, alum	63 P/14	4
Piteean, potstone	——	458
Rohtasgarh, alum	63 P/14	4
„ limestone	„	33
„ lithographic stone	„	310
„ sulphate of iron	„	467
Sugia-Koh R., alum	——	4
Sulya, iron	63 P/9	244
Surki „	——	244
Singhbhum, bismuth	..	23
„ slate	„	33
„ sulphide ores	„	472
Anandapur, gold	73 F/3	195
Asantoria „	73 F/10	195
Buda hill, iron	73 F/7	245
Chingijari „	73 F/10	245
Dhipa, gold	73 F /3	195
Duarparam, copper	73 F/9	119
Koel R., gold	73 F/3	195
Leda hill, manganese	73 F/7	321
Pahardiah, gold	73 F/2	195

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	Sheet.	Page.
BIHAR & ORISSA—*contd.*		
Singhbhum—*contd.*		
Pahardiah, silver-lead	73 F/2	295
Pansira (Notu hill), iron	73 F/7	245
Porahat, gold	73 F/6	195
Sanjai R., „	73 F/6	195
Sausal „	73 F/6	196
Sukha R., „	73 F/7	196
Tendu, iron	73 F/10	245
(Dhalbhum)—		
Belaipahari, potstone	73 J/5	458
Bhairagora, copper	73 J/11	119
Dari, potstone	73 J/2	458
Domapal „	73 J/11	458
Gurha R., gold	73 J/6	195
Hakigora, iron	73 J/2	245
Kalimati, tungsten	73 J/1	485
Kamerara, gold	73 J/11	195
Kapargadi pass, gold	73 J/6	195
Landu (Nadup), copper	73 J/2	120
„ „ gold	„	195
Laukisra, copper	73 J/6	120
Matigara „	73 J/6	120
Moosalbali (? Mosalboni), apatite	73 J/6	424
Narsinghpur, potstone	73 J/6	457
Pathorgora, apatite	73 J/6	424
Rajdoha, copper	73 J/6	121
„ gold	„	195

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	Sheet.	Page.
BIHAR & ORISSA—*contd.*		
Singhbhum (Dhalbhum)—*contd.*		
Sakchi, iron	73 J/1	242
Sidesher, potstone	73 J/6	458
Tikri, potstone	73 J/6	458
Tilai jhor, potstone	73 J/2	458
Turamdih, iron	73 J/2	245
(Kharsawan), ochre	..	393
Kodomdiha, copper	73 F/13	120
Lopso hill, corundum	73 F/9	139
Regadih, copper	73 F/9	121
Sonapet, gold	73 F/9	196
(Kolhan), ochre	..	393
Bistampur (Matagota), manganese	73 F/15	320
Chaibasa, iron	73 F/14	245
„ manganese	„	320
Gitilpi, manganese	73 F/14	320
Jogohatu, iron	73 F/10	245
Kalenda, manganese	73 F/15	321
Lagia, iron	73 F/10	245
„ manganese	„	321
Matkamhatu, manganese	73 F/14	321
Sura pass, chromite	73 F/10	63
Tekrasai, manganese	73 F/14	321
Tutugutu, „	73 F/15	321
(Saraikela)—		
Dubrajpur, potstone	73 J/2	458
Jamjura, copper	73 J/2	120

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	Sheet.	Page.
BIHAR & ORISSA—*contd.*		
Singhbhum (Saraikela)—*contd.*		
Koraikela, potstone	73 F/10	458
Palakucha „	73 J/2	458
Talcher, coal	..	84
„ iron	..	243
Gopulpersad, coal	73 H/1	85
Ouli R., gold	73 C/16	196
Tikiria R., gold	73 C/16	196
BOMBAY—		
Ahmadabad—		
Harsol, mineral water	46 E/3	378
Ranpur, agate	41 N/11	152
Ahmadnagar—		
Rasin, copper	47 J/15	121
Sina R., opal	47 N/8	175
Baroda—		
Achali, quartzite	46 F/11	34
Bhadrali, gneiss	46 F/12	34
Bhulvan, granite	46 F/12	34
Harikua, marble	46 F/12	34
Lacharas hill, quartzite	46 F/12	34
Motipura, marble	46 F/12	34
Sandara, marble	46 F/12	34
Sandia (Kundia), siliceous breccia	46 F/12	34
Sihadra, quartzite	46 F/16	34
Songir, sandstone	46 F/12	35

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	Sheet.	Page.
BOMBAY—*contd.*		
Baroda—*contd.*		
Surajpur, slate	46 F/11	35
Tandalja, felsite	46 F/12	34
Virpur, granite	46 A/14	34
Belgaum—		
Belvadi, gold	48 I/14	196
Bhimgad, manganese	48 I/6	321
Ganibail, granitoid gneiss	48 I/10	35
Gokak Falls, alum	47 L/16	4
Hongal, gold	48 I/12	196
Khanapur, granitoid gneiss	48 I/10	35
Manikehri, manganese	47 P/4	321
Murgod, gold	48 I/13	196
Nagargali, manganese	48 I/11	321
Nersa ,,	48 I/6	321
Talevadi, ,,	48 I/6	321
Tawargatti ,,	48 I/11	322
Bijapur—		
Aiholi (Iwulee), sandstone	47 P/16	35
Amingarh, iron	47 P/16	246
Bagalkot, lithographic stone	47 P/12	310
,, manganese	,,	322
Bassargi, iron	48 M/1	246
Bijapur, basalt	47 P/9	35
Bilgi, building stone	47 P/11	35
Bisnal, iron	47 P/7	246
Dhanur, hornblende—schist	56 D/4	36

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	Sheet.	Page.
BOMBAY—*contd.*		
Bijapur—*contd.*		
Gudur, sandstone	48 M/13	35
Guludgud, gold	47 P/16	197
Haligeri, flag-stone	48 M/5	35
Hunugund, schist	56 D/4	35
Ingleswara, manganese	56 D/2	322
Kacherdawi (Khajjidoni), copper	47 P/8	121
Kaladgi, limestone	47 P/12	35
Lokapur, slate	47 P/8	36
Maileshwar, limestone	56 D/7	35
Parvati, sandstone	47 P/16	35
Silikeri, slate	47 P/12	36
Sitadonga hill, ochre	47 P/12	393
Talikot, lithographic stone	56 D/7	310
„ salt	„	439
„ slate	„	36
Broach—		
Kawa, mineral water	46 B/12	378
Chota Udaipur—		
Gabadia hills, mica	46 J/3	366
Moriari (? Muthyari), iron	46 F/15	248
Pani, manganese	46 F/15	323
Cutch, sandstone	..	36
Adesar, gypsum	41 I/14	226
Adkui, gypsum	41 I/11	226
Badargarh, gypsum	41 I/11	226

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	Sheet.	Page.
BOMBAY—*contd.*		
Cutch—*contd.*		
Bhuj, coal	41 E/11	85
„ limestone	„	36
Buchao, iron	41 I/7	246
Chachera Kund, alum	41 A/14	5
Charwar range, miliolite	41 E/12	36
Chitrore, gypsum	41 I/11	226
Dudhai, iron	41 I/3	246
Lakhpat, ochre	41 A/13	393
„ salt	„	436
Mhurr, alum	41 A/14	4
„ gypsum	„	226
„ mineral water	„	378
Patcham I., marble	41 E/13	36
Raimalru hill, limestone	41 E/9	36
Sisagadh, coal	41 E/8	85
Trombow (Trambau), coal	41 E/11	85
Umarsar, gypsum	41 A/14	226
Dharwar, potstone	..	458
Attikatti (Hutteekuttee), gold	48 M/11	197
Chik Vadvati, manganese	48 M/12	322
Dambal, gold	48 M/15	197
Dhoni, copper	48 M/11	121
„ gold	„	197
„ limestone	„	36
Gadag, chloritic schist	48 M/11	36
Hamigi, manganese	48 M/16	322

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	Sheet.	Page.
BOMBAY—*contd.*		
Dharwar—*contd.*		
Hosur, gold	48 M/11	197
Kabulayatkatti (Kabligatti), gold	48 M/11	197
Kappatgod hills, copper	48 M/11	121
„ „ gold	„	197
„ „ tin	„	477
Surtur, copper	48 M/12	121
„ gold	„	197
(Sangli)—		
Kelur, manganese	48 M/16	322
Shirhatti, manganese	48 M/12	323
Idar—		
Ahmadnagar, sandstone	46 A/14	37
Dev Mori, asbestos	46 E/6	16
„ „ magnesite	„	312
„ „ steatite	„	458
Ghanta, steatite	46 E/6	459
Kokapur, magnesite	46 E/6	312
Kundol, steatite	46 E/6	459
Sabarmati R., monazite	46 A	390
Kaira—		
Kapadvanj, agate	46 E/4	152
Lasundara, mineral water	46 F/1	378
Majam R., agate	46 E/4	152
Kathiawar—		
(Baroda)—		
Amreli, basalt	41 O/2	37

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	Sheet.	Page.
BOMBAY—*contd.*		
Kathiawar (Baroda)—*contd.*		
Bardia, marble	41 F/4	38
Damnagar, acidic trap	41 O/10	37
Dhalkania, acidic trap	41 O/10	37
Gaodka, basalt	41 O/2	37
Kodinar, miliolite	41 L/9	38
Kuranga, gypsum	41 F/4	226
Pipalwa, marble	41 O/4	38
Rajpura Bandar, limestone	41 F/4	38
Rupavati, diorite	41 O/4	37
Sakhpur, acidic trap	41 O/10	37
Shedaya, limestone	41 L/13	38
(Bhavnagar), gypsum	..	226
(Dhrangadra)—		
Baoli, sandstone	41 N/5	37
Dhrangadra, sandstone	41 N/5	37
Kantrori, iron	41 N/5	246
(Gondal)—		
Khirasra, marble	41 K/5	37
Sajriali ,,	41 K/5	37
(Junagarh)—		
Banej-nes, copper	41 K/16	122
,, lead	,,	295
Sourekha R., gold	41 K/10	198
Tulsi Sham, mineral water	41 O/4	378
(Lakhtar)—		
Than, coal	41 N/2	85

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	Sheet.	Page.
BOMBAY—*contd.*		
Kathiawar—*contd.*		
(**Limbdi**), borax	..	24
(**Morvi**)—		
Khijaria, agate	41 J/9	153
Tankara, jasper	41 J/13	174
„ rock-crystal	41 J/13	176
(**Navanagar**) miliolite	..	38
Alech hills, felsite	41 K/1	38
Badanpur, moss agate	41 J/9	153
Baolidar, onyx	41 J/4	175
Bhatia, gypsum	41 P/8	226
„ iron	„	247
Bhudli, copper	——	122
Bori, onyx	41 J/4	175
Cheque Dhar, iron	41 G/13	247
Habardi, iron	41 F/8	247
„ laterite (habardilite)	„	38
Hariawar, ochre	41 F/8	393
Jam Jodhpur, iron	41 K/1	247
Jivapur, moss agate	41 J/9	153
Khakhra, moss agate	41 J/7	153
Khokhra Dhar, iron	41 G/5	247
Khokhri, onyx	41 J/7	175
Latipur, moss agate	41 J/10	153
Maha Devia, iron	41 F/8	247
Nandana, gypsum	41 F/8	226
Narmana, onyx	41 J/4	175
Navanagar, copper	41 J/3	122

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	Sheet.	Page.
BOMBAY—*contd.*		
Kathiawar (Navanagar)—*contd.*		
Otala, moss agate	41 J/10	153
Pindara, limestone (pindaralite)	41 F/8	38
Ramwara R., laterite (ramwaralite)	41 F/4	38
Ran, gypsum	41 F/8	226
Raningpur, palagonite	41 N/4	38
Sambelia Bet, iron	41 F/7	247
Tamba Talao „	41 F/8	247
Thoriali, moss agate	41 J/10	153
Timbri „ „	41 J/10	153
Veratia, agate	41 J/7	153
Vijarkhi, onyx	41 J/3	175
Virpur, gypsum	41 F/7	226
(Porbandar)—		
Bakharla, iron	41 G/10	246
Barda hills, felsite	41 G/10	38
„ „ miliolite	„	37
Ranawao, iron	41 G/10	246
Ranpur, iron	41 G/9	246
„ miliolite	„	37
Kolaba—		
Pali, mineral water	47 F/2	378
Sapa (Savi), mineral water	47 F/8	378
Narukot—		
Dhola Sodur hill, mica	46 F/11	366
Jambughoda, iron	46 F/11	247
„ tin	„	477

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	Sheet.	Page.
BOMBAY—*contd.*		
Narukot—*contd.*		
Jhuban (? Jaban), lead	46 F/11	295
Jothvad, apatite	46 F/11	425
„ manganese	„	324
Khandivav Lake, lead	46 F/11	295
Narukot, iron	46 F/11	248
North Kanara—		
Supa, manganese	48 I/11	323
Palanpur—		
Hosainpura (Hoshanpur), gadolinite	45 D/11	431
„ „ manganese	„	323
„ „ tin	„	477
Rohu, manganese	45 D/11	323
Panch Mahals—		
Sivarajpur, manganese	46 F/11	323
Tuwa (Tui) mineral water	46 F/9	379
Poona—		
Loni Kalbhar, soda	47 J/3	453
Sirur, soda	47 J/5	453
Rajpipla—		
Bardaria hill, trachyte	46 G/6	39
Bhilod, gypsum	46 G/2	226
Damlai, kaolin	46 G/2	286
Deva R., sandstone	——	39
Dodvada, gypsum	46 G/2	227
Dungri, iron	46 G/2	248
Gora, marble	46 G/2	39

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	Sheet.	Page.
BOMBAY—*contd.*		
Rajpipla—*contd.*		
Karia hill, trachyte	46 G/6	39
Limodra, agate	46 G/2	153
„ iron	„	248
„ manganese	„	324
Mokhadi, marble	46 G/9	39
Mota Amba, tuff	46 G/9	39
Padvania, ochre	46 G/2	393
Rajpipla, tuff	46 G/9	39
Ratanpur, agate	46 G/2	153
Sakva, sandstone	46 G/9	39
Samaria, tuff	46 G/9	39
Todakhail R., marble	46 G/13	39
Vanji, marble	46 G/13	39
Vasna, bauxite	46 G/2	22
Zulta Amda, marble	46 G/13	39
Ratnagiri—		
Arauli, mineral water	47 G/11	379
Asgani, potstone	47 H/12	459
Malvan, iron	47 H/8	247
Mat, mineral water	47 H/5	379
Rairi (Reri), iron	48 E/10	247
„ „ manganese	„	323
Rajapur, mineral water	47 H/10	379
Ratnagiri, lignite	47 H/5	307
Sangameshwar, mineral water	47 G/12	379
Tural (Rajwadi), mineral water	47 G/12	379

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	Sheet.	Page.
BOMBAY—*contd.*		
Ratnagiri—*contd.*		
Unari, mineral water	47 G/6	379
Vingorla, copper	48 E/9	122
(Savantvadi)—		
Banda, iron	48 E/13	247
Savantvadi, iron	48 E/13	247
Satara—		
Kas, manganese	47 G/14	324
Khanapur, manganese	47 K/11	324
Mahableshwar, bauxite	47 G/9	21
,, iron	,,	248
,, manganese	,,	324
Wai, manganese	47 G/13	324
Sind—		
Hyderabad, fullers' earth	40 C/7	150
(Karachi)—		
Bandh Vera, iron	40 C/2	248
Bill, alum	35 O/6	5
Ghizri Bandar, sulphur	35 P/1	472
Jain Pir, mineral water	40 C/4	379
Jhirak, limestone	40 C/4	39
Karachi ,,	35 L/13	39
Kotri, iron	40 C/7	248
Lainyan, coal	40 C/2	85
,, iron	,,	248
Laki, mineral water	35 N/15	379
,, sulphur	,,	472

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	Sheet.	Page.
BOMBAY—*contd.*		
Sind—*contd.*		
(Karachi)—*contd.*		
Laki range, fullers' earth	35 N/15	150
Manga (Mugger) Pir, mineral water	35 P/1	379
Ranikot, alum	35 O/13	5
Thano-Bule-Khan, celestite	35 O/15	469
Wagodur, mineral water	35 P/1	380
(Larkhana)—		
Gaj R., gypsum	35 N/5	227
Maki Nai, alum	35 M/8	5
Pith (Ghazipur), mineral water	35 N/7	380
Sehwan, mineral water	35 N/15	380
Shah Hassan, alum	35 N/11	5
(Sukkur)—		
Sukkur, limestone	40 A/14	39
„ petroleum	„	404
Surat—		
Anaval (Devaka Unei), mineral water	46 H/5	380
Tarkeshwar, bauxite	46 G/3	21
„ limestone	„	40
Thana, basalt	..	40
Kokner, mineral water	47 A/14	380
Thal Ghat, basalt	47 E/6	34
Satiwali, mineral water	47 A/13	380
Vesava I., limestone	47 A/16	40
Vizrabhai, mineral water	47 E/3½	380

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BURMA—		
Akyab—		
Baranga Is., petroleum	85 E/1	406
Krinkhwaimau, petroleum	84 D/15	406
Nataran, petroleum	84 D/13	406
Amherst—		
Ataran R., antimony	94 H/15	11
„ bismuth	„	23
„ fire-clay	„	148
„ iron	„	249
„ mineral water	„	380
„ sulphate of iron	„	467
Gyaing R., fire-clay	94 H/14	148
„ iron	„	249
„ manganese	„	325
Houndran (? Haung-tha-raw) R., lead	95 I/10	295
Kyiek Myram, copper	——	122
Lekka Taung, antimony	94 H/12	11
Megathat R., copper	95 I/7	122
Maulmein, fire-clay	94 H/11	147
„ lead	„	295
„ limestone	„	40
Natmoo, mineral water	94 H/11	381
Sienli „ „	94 H/11	381
Zimmé (Zami) R., antimony	95 I/6	11
„ „ „ lead	„	295
Bassein—		
Banmi, limestone	85 K/11	40

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	Sheet.	Page.
BURMA—*contd.*		
Bassein—*contd.*		
Bassein R., gold	85 L/9	198
Korangyi I., limestone	85 L/6	40
Thamandewa, „	85 L/11	40
Bhamo—		
Mithwé, coal	92 D/16	85
Molé Kyaung, gold	92 H/3	198
Myothat, gold	92 H/7	198
Ponsee (Ponshi), lead	92 H/11	295
Taping R., gold	92 H/7	198
Chindwin (Lower)—		
Alôn, gold	84 N/4	198
Bawdibin, petroleum	84 J/10	408
Kani, gold	84 J/15	198
„ platinum	„	427
Letpadaung hill, copper	84 N/4	122
Taungdwin Kyaung, petroleum	84 J/6	408
Thazi, gold	84 N/8	198
Chindwin (Upper)—		
Edi R., salt	92 B/7	436
Gyogon, gold	83 L/12	199
Helaw, gold	83 L/12	199
Hukawng valley, amber	92 B	9
„ „ gold	„	199
„ „ platinum	„	427
Indin, petroleum	84 I/4	408
Kalewa, coal	81 I/8	86

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	Sheet.	Page.
BURMA—*contd.*		
Chindwin (Upper)—*contd.*		
Kapdup R., gold	92 B/15	199
Khaung-ngo, gold	83 P/1	199
Kindat, lignite	84 I/6	307
Kyobin, gold	83 P/5	199
Maglung (Yu) R., salt	83 L/8	436
Mainghkwan, amber	92 B/7	9
Maku R., coal	84 I	86
Mekkalek, gold	——	200
Namkwan R., gold	92 B/7	199
Nam-won-kôk R., salt	92 B	436
Nantahin R., coal	84 I	86
Ningthee (Chindwin) R., gold	83 L	198
Peluswa R., coal	84 I	86
Telong R., „	84 I	86
Uyu R., gold	83 P	199
Yenan, petroleum	84 I/5	408
Yenatha „	84 I/4	408
Ywatha, gold	83 L/12	199
Henzada, nickel	..	391
„ salt	..	437
Endeingôn, kaolin	85 O/1	287
Hlemauk, coal	85 O/1	86
Kyibin, graphite	85 K/14	220
Kywezin, coal	85 O/1	86
Posugyi „	85 N/4	86
Sahdwingyi, salt	85 N/4	437

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	Sheet.	Page.
BURMA—*contd.*		
Henzada—*contd.*		
Wadawkwin, graphite	85 O/2	220
Yenandaung, petroleum	85 N/4	408
Insein—		
Engsein (Insein), manganese	94 D/1	325
Karenni—		
Keh-daung (Mawchi), tin	94 F/1	480
„ „ tungsten	„	485
Kyai Kyaung, mineral water	——	381
Myet-nan-Kyaung, gold	——	200
Namon, tourmaline	94 E/7	183
Ye-bu, mineral water	——	381
Katha (Wuntho)—		
Banmauk, gold	83 P/15	201
Kaydwin, silver-lead	83 P/12	296
Kyaukpazat, gold	83 P/16	200
Maingthon hill, salt	83 P/12	436
Mawkwin, lead	83 P/12	296
Meza R., gold	92 D/4	200
„ platinum	„	427
Pinlebu, coal	83 P/8	87
Yuyinbyet coal	83 P/8	87
Kyaukpyu—		
Cap I., coal	85 E/7	87
Cheduba I., coal	85 F	87
„ petroleum	„	406
Hpa-aing, steatite	84 L/7	459

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	Sheet.	Page.
BURMA—*contd.*		
Kyaukpyu—*contd.*		
Kyaukpyauk, petroleum	85 E/11	407
Ledaung, petroleum	85 E/12	407
Minbyin (Yenandaung), petroleum	85 E/12	407
Myingadé hill, steatite	——	459
Pallang Roa, coal	85 F/10	87
Ramri I., coal	85 E	87
„ iron	„	249
„ limestone	„	41
„ petroleum	„	406
Round I., copper	85 F/14	122
Synkyaung, coal	85 E/11	87
Tsetama, coal	85 F/13	87
Yanthek, limestone	85 E/16	41
Kyauksé—		
Kyauksé, marble	93 C/2	41
Myogyi, gold	93 C/6	201
Magwé—		
Bemé, petroleum	84 L/15	411
Khodaung, petroleum	84 L/15	411
Kyundaw, petroleum	85 M/1	408
Migyaungé, petroleum	85 M/1	408
Ondwe, petroleum	84 P/4	409
Twingon, petroleum	82 L/15	411
Wetchok, petroleum	84 P/3	409
Yedwet, petroleum	84 P/2	409

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	Sheet.	Page.
BURMA—*contd.*		
Magwé—*contd.*		
Yenangyaung, manganese	84 L/15	325
,, petroleum	,,	409
Mandalay—		
Sagyin, marble	93 B/3	41
,, ruby	,,	178
Singaung (Zegôn), iron	93 C/5	249
Tonbô, limestone	93 C/1	41
Twinngé, iron	93 C/5	249
Wetwin, coal	93 B/12	90
,, iron	,,	249
Zebingyi, limestone	93 C/5	41
Meiktila—		
Lebya, petroleum	84 O/12	413
Legaung, coal	93 D/9	90
Pyinnyaung, lead	93 D/5	298
Titpalwigôn, coal	93 D/9	90
Mergui—		
A-tong-wo, coal	96 I/15	88
Banhuni, tin	96 J/10	480
Bokpyin, tin	96 I/16	480
Ch'hando (Kyando) tin	95 K/11	480
Davies I., tin	96 K/1	483
Gna I., manganese	95 L/7	325
Hangpru, tin	96 I/16	481
Hesamkong, tin	96 M/2	481
Horsborough I., gold	96 G/16	201

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	Sheet.	Page.
BURMA—*contd.*		
Mergui—*contd.*		
Kahan hill, tin	95 L/16	481
Kala-khuing I., iron	96 I/9	249
Kala-Kyauk I., copper	95 L/11	122
Kamapying, coal	95 P/3	88
Karathuri, tin	96 J/13	481
Kings' I., tin	95 L/6	483
Kissering (Kit-tha-yin) I. tin	96 I/6	483
Kumong, manganese	96 J/12	325
Kyaung-kapra, tin	96 J/13	481
Kyaung-ta-naung, tin	96 J/9	481
Lamaing R., gold	——	201
Lampei (Sullivan) I., copper	96 J/1	122
Lenya R., coal	96 I/15	88
,, tin	,,	481
Loungdoungin R., tungsten	95 P/4	485
Maingay's I., silver-lead	95 L/6	296
Maliwun, tin	96 J/12	478, 481
Maoin (Meaing)I., iron	95 L/7	249
Mazaw, tin	95 L/15	482
Mergui, tin	95 L/11	482
Migyaung Kyaung, tin	96 I/11	482
Palauk, mineral water	95 K/11	381
Russel I., gold	——	201
Sadien, tin	96 I/15	482
Tagu, tin	95 P/3	482
Tenasserim R., coal	95 P/4	87

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	Sheet.	Page.
BURMA—*contd.*		
Mergui—*contd.*		
Tenasserim R., gold	95 P/4	201
„ kaolin	„	287
Tendau (Ta-the-na), coal	95 P/3	87
„ „ tin	„	482
Thabalik, tin	95 P/4	482
Thagu R., manganese	——	325
Tharapôn, tin	95 L/16	482
Therabwin, graphite	95 P/3	220
„ iron	,	250
„ manganese	„	325
To-twé, tin	96 I/12	482
Tsingkoon, coal	95 P/4	87
White Pigeon I., iron	——	249
Yamôn, tin	95 L/12	483
„ tungsten	„	485
Ye-ngan, tin	96 I/15	483
Minbu—		
Kyet-u-bok, petroleum	85 I/9	414
Minbu, petroleum	84 L/16	413
Ngahlaingdwin, petroleum	84 L/6	414
Ngapé, petroleum	84 L/8	414
Peinhnebin, petroleum	84 L/12	414
Penlan, steatite	85 I/5	460
Mŏngmit (Momeik), ruby	..	178
Maingnin, tourmaline	93 A/16	183

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	Sheet.	Page.
BURMA—*contd.*		
Myingyan—		
Gwegyô, petroleum	84 P/1	414
Kabat (Seiktein), manganese	84 O/8	325
„ „ petroleum	„	415
„ „ sulphate of iron	„	467
Ngashandaung, petroleum	84 P/2	415
Pagan, petroleum	84 K/16	415
Panbé, ochre	84 P/1	393
Payagyigôn, petroleum	84 P/2	415
Popa (Puppa) hill, iron	84 P/1	250
Sagyin, salt	84 P/5	437
Singu, petroleum	84 L/13	415
Taungtha hill, petroleum	84 O/7	416
Tetma, petroleum	84 L/13	415
Welaung, petroleum	84 O/8	416
Myitkyina—		
Hweka, iron	92 C/3	250
„ jadeite	„	282
Indaw R., mica	92 C/7	367
Irrawaddy R., gold	92 G/6	201
„ platinum	„	427
Malikha, gold	92 G/6	201
Mamôn, jadeite	92 C/6	282
Manwé, ruby	92 C/11	179
Naniazeik, ruby	92 C/10	179
'N Maikha, gold	92 G/10	201
Pungin Kha, spinel	92 G/5	183

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BURMA—*contd.*		
Myitkyina—*contd.*		
Supya Kyaung, mineral water	——	381
Talang, lignite	92 G/5	307
Tammaw, chromite	92 C/2	63
„ jadeite	„	281
Uru (Uyu) R., iron	92 C/3	250
Watu, spinel	92 G/6	183
Pakokku—		
Chaungzongyi, gold	84 K/13	201
Kyaukswé, petroleum	84 K/4	416
Kyaukwet, petroleum	84 K/10	416
Kyin, petroleum	84 K/6	416
Kyun Kyaung, amber	84 K/16	10
Letpanhla, coal	84 K/7	89
Man, petroleum	84 K/7	416
Myaing, petroleum	84 K/14	416
Sabé, petroleum	84 K/15	417
Shinmadaung, petroleum	84 O/2	416
Suwin, petroleum	84 K/10	416
Taus, coal	84 K/7	89
Yaw R., coal	84 K/7	88
Yebyu, petroleum	84 K/6	416
Yenangyat, petroleum	84 K/16	416
Prome, iron	..	250
„ salt	..	437
Namayan, petroleum	85 N/1	418
Padaung (Kayinzu), petroleum	85 N/2	418

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	Sheet.	Page.
BURMA—*contd.*		
Prome—*contd.*		
Paukkaung, petroleum	85 N/9	418
Shinbaian hill, steatite	85 J/13	460
Taungbogyi, petroleum	85 N/1	418
Ziaing (Thingan), petroleum	85 N/1	418
Ruby Mines—		
Kyatpyin, ruby,	93 B/5	178
Kyaukgyi, graphite	93 B/1	221
Mogôk, apatite	93 B/9	156
„ marble	„	41
„ ruby	„	179
„ sapphire	„	181
„ spinel	„	183
„ tourmaline	„	184
Shwenyaungbin, ruby	93 B/5	179
Thabeikkyin, marble	93 B/1	41
Wabyudaung, graphite	93 B/1	220
Ye-nya-u, mica	93 B/1	366
Sagaing, asbestos	..	16
„ manganese	..	325
Yega, copper	84 O/13	122
„ salt	„	437
Salween—		
Mizine, silver-lead	94 G/11	296
Teetalay (Titalet) hill, lead	94 G/6	296
Teetameelay (? Yomakyo) hill, silver-lead	94 F/4	296
Yetagôn, manganese	94 G/15	325

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	Sheet.	Page.
BURMA—*contd.*		
Salween—*contd.*		
Yunzalin R., alum	94 G	5
,, copper	,,	123
Sandoway—		
Kingtelli (Kyintali), lignite	85 J/8	307
Sandoway, steatite	85 J/7	460
Shan States (Northern), mercury	..	364
(Hsipaw)—		
Bawgyo (Maw-hkeo), salt	93 F/2	437
,, ,, sulphate of soda	,,	468
Hsipaw, sandstone	93 F/6	42
Hsum Hsai, antimony	93 B/11	12
Mong-ting, coal	93 F/13	90
Namma, coal	93 F/14	90
Namon, mineral water	93 F/3	381
Namsaw, lead	93 B/14	297
Padaukpin, marble	93 B/12	41
(Möng-Long)—		
Hwe-gna-sang, gold	93 B/6	202
Kungwo, gold	93 B/6	202
Letpandaw, copper	93 B/11	123
Loi Sar, gold	93 B/6	202
Nampai R., tourmaline	93 B/9	184
(Möng Tung), gold	..	202
Man Hpwé, lead	93 F/16	297

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	Sheet.	Page.
BURMA—*contd.*		
Shan States (Northern)—		
(North Hsenwi)—		
Lashio, coal	93 F/13	89
„ mineral water	„	381
(South Hsenwi)—		
Man Sang, coal	93 F/15	90
Man-se-lé, coal	93 J/2	90
Namma, gold	93 J/5	202
(Tawng Peng)—		
Bawdwin, barytes	93 E/8	18
„ copper	„	123
„ silver-lead	„	296
„ zinc	„	297, 488
Hungwé, pyrites	93 E/4	473
Loi Mi, copper	93 E/8	123
Man Pat, pyrites	93 B/4	473
Nam Hsan, antimony	93 F/1	12
Shan States (Southern)—		
(Kehsi Mansam)—		
Keshi Mansam, mineral water	93 G/13	381
Loi Twang, gold	93 G/9	202
„ „ iron	„	250
(Kengtung)—		
Mong Ping, mineral water	93 O/3	381
Waihang, mineral water	93 K/16	381
(Möng Küng), gold	..	202
(Myelat)—		
Bwelôn, silver-lead	93 D/13	297

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	Sheet.	Page.
BURMA—*contd.*		
Shan States (Southern)—**(Myelet)**—*contd.*		
Dwinzu, silver-lead	93 D/13	297
Ganaingya, copper	93 C/12	124
Kalaw, tungsten	93 D/10	487
Kwe-ma-sa, copper	93 D/10	124
Magwé, copper	93 D/10	124
„ gold	„	203
Mawsün (Bawzain), pyrites	93 D/13	473
„ „ silver-lead	„	297
Myinkyardo, lead	93 D/9	298
Mam Tôk, saltpetre	94 A/13	450
Nangôn, lignite	93 D/9	307
Nga (Ngotko yaygi), coal	93 D/9	91
Nyaungya, tungsten	93 C/8	487
Panlaung R., coal	93 C/8	91
Po-pyu, coal	93 D/10	91
Taunglebyin, copper	93 D/6	123
„ gold	„	203
Yataung hill, copper	93 D/9	123
Yebok, sulphur	93 D/9	473
(Yawnghwe)—		
Kyarktat (Kyawk Htap), copper	93 D/13	123
„ „ „ silver lead	„	297
Thygyit (Hsikip), lignite	93 D/14	307
Shwebo, salpetre	..	450
Halin, salt	84 N/15	438
Kabwet, coal	84 N/14	91

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	Sheet.	Page.
BURMA—*contd.*		
Shwebo—*contd.*		
Ketzubin, coal	84 N/14	91
Kibiung R., coal	84 N/13	91
„ gold	„	203
Kyunhla, petroleum	84 M/7	418
Letkobin, coal	84 N/14	91
Mantha, amber	84 N/13	10
Ponnah R., gold	84 N/13	203
Shimpagah (? Shinmaga), salt	84 N/15	438
Tembiung, coal	84 N/13	91
Thingadaw, coal	84 N/13	91
„ gold	„	203
Tavoy, antimony	..	12
„ columbite	..	430
„ molybdenum	..	389
„ zinc	..	489
Byauk Kyaung, tungsten	95 J/3	486
Dzin Ba Kyaung, gold	95 J/2	203
Eng-bein-byin, (Yebu-san), mineral water	95 J/2	382
Heinda R., tin	95 J/8	483
Heindu R., tin	95 J/8	483
Henzai (Heinzé), cobalt	95 F/14	112
„ „ gold	„	203
„ „ platinum	„	427
„ „ tin	„	483
Hermyingyi (Hamyingyi), tin	95 J/8	484
Im-Ba-Kyaung, gold	95 J/1	203

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	Sheet.	Page.
BURMA—*contd.*		
Tavoy—*contd,*		
Kalliaung (? Ka-lein-aung), ochre	95 J/2	394
Kalonta Kyaung, tin	95 J/7	484
„ „ tungsten	„	486
Laukyen (Laukchan), mineral water	95 J/8	382
Maungmeshaung, tin	95 J/4	483
Myittha, alum	95 J/12	6
„ mineral water	„	382
„ tin	„	483
Ongbingwin, tin	95 F/14	484
Pa Kyaung, tungsten	95 J/2	486
Pai, mineral water	95 K/11	382
Sanchi R., tungsten	95 J/8	485
Tavoy, iron	95 J/4	250
Thangazôn, tungsten	95 J/8	486
Thingadôn, „	95 J/8	486
Wagôn, tin	95 J/8	484
Tharrawaddy—		
Shwegyaing, gold	85 N/8	202
Thaton, tin	..	484
„ tungsten	..	487
Botaung hills, copper	——	123
Kalagauk I., granitoid gneiss	94 H	42
Pagah range, copper	94 G	122
„ „ silver-lead	„	295
Quangdé (Quangadu), antimony	94 H/10	11
Thaungyin R., manganese	94 G	324

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	Sheet.	Page.
BURMA—*contd.*		
Thayetmyo, salt	..	437
Aukmanein, petroleum	85 I/16	418
Bambyin ,,	85 M/3	418
Kama ,,	85 M/4	419
Kyauk-kale, coal	85 I/11	92
Kyawdo, petroleum	85 I/14	419
Linga ,,	85 I/14	419
Mindegyi ,,	85 I/13	419
Monat Kon ,,	85 M/1	419
Padaukpin ,,	85 M/3	419
Pyalo ,,	85 M/4	419
Sinmadaung ,,	85 M/1	419
Thabyemyaung (Thetkemyaung), petroleum	85 I/13	419
Thayetmyo, coal	85 M/3	92
,, limestone	,,	42
Yegubwet, petroleum	85 I/9	419
Yenanman ,,	85 I/13	419
Toungoo, manganese	..	325
Kanni R., graphite	——	221
Shanlebyin, petroleum	94 A/11	419
Shwegyin, gold	94 C/13	203
Thanzeik, iron	94 B/16	251
Toungoo, sandstone	94 B/5	42
Yondaing, iron	94 B/16	251
Yamethin—		
Mt. Pima, silver-lead	93 D/6	298

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CENTRAL INDIA AGENCY—		
Bhopal—		
Kanugaon, manganese	55 E/7	326
Bijawar, iron	..	251
Simra, diamond	63 D/1	162
Charkari—		
Bajaria, diamond	63 D/6	162
Khameria „	63 D/5	162
Patti „	63 D/5	162
Ranipur „	63 D/5	162
Chobpur—		
Dia, diamond	63 D/9	162
Jhanda „	63 D/9	162
Seha „	63 D/5	162
Datia—		
Nardha (Seonhra), lead	54 J/16	298
Dhar (Nimanpur)—		
Bhaurikhera, iron	55 B/7	251
Jhirpania „	55 B/7	251
Kanar manganese	55 B/3	326
Katotia „	55 B/7	326
Kheria Kund „	55 B/7	326
Pan Kuan „	55 B/6	326
Pola Khal „	55 B/7	326
Ratagarh „	55 B/3	326
Gwalior, salt	..	438
Aindhar, lead	54 K/2	298
Antri, kaolin	54 J/4	287

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CENTRAL INDIA AGENCY—*contd.*		
Gwalior—*contd.*		
Bagh, iron	46 J/15	251
„ slate	„	43
Behat, manganese	54 J/12	326
Gwalior, sandstone	54 J/4	43
Karhia, copper	54 K/1	124
„ lead	„	298
Mangor, iron	54 J/4	251
Morar, glass-making sand	54 J/4	186
Par hill, iron	54 J/4	251
Ragonathpur, lead	54 J/8	298
Raipur, fire-clay	54 J/4	148
Santow, iron	54 J/4	251
(Malwa)—		
Piplauda, soda	46 M/7	453
Indore (Nimawar)—		
Bain, iron	55 B/11	252
Barel, manganese	55 B/3	327
Barwai, iron	55 B/3	252
„ marble	„	43
Bhamar, manganese	55 B/11	327
Bowarla, marble	46 N/3	43
Chiktimodri, iron	55 B/3	252
Chirakhan, marble	46 N/3	43
Ghatia, sandstone	55 B/3	43
Jiwani, copper	55 B/11	124
Kanar R., manganese	55 B/3	327

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	Sheet.	Page.
CENTRAL INDIA AGENCY—*contd.*		
Indore (Nimawar)—*contd.*		
Karondia, iron	55 B/3	252
Katkut, sandstone	55 B/3	43
Kharia, copper	55 B/11	124
Kherwan, marble	46 N/3	43
Mendikhaira, iron	55 B/3	252
Nandnia „	55 B/3	252
Rupabari, sandstone	55 B/4	43
Sendrani, iron	55 B/11	252
Tamkhan, copper	55 B/15	124
Jhabua—		
Amlamal, manganese	46 I/8	327
Kajlidongri, „	46 J/5	327
Kanas, mica	46 J/10	367
Piplade, iron	46 J/9	252
Pitol, manganese	46 J/5	328
Rambhapur „	46 J/5	327
Ranapur, mica	46 J/10	367
Sanar R., iron	46 J/9	252
Tumdia, manganese	46 J/6	328
Jobat, asbestos	..	16
Kothi—		
Jhanda, diamond	63 D/9	163
Naigawa (Neagaon), diamond	63 D/13	163
Panna, ochre	..	394
Babupur, diamond	63 D/5	162

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	Sheet.	Page.
CENTRAL INDIA AGENCY—*contd.*		
Panna—*contd.*		
Bandi diamond	63 D/2	162
Birjpur „	63 D/5	162
Durgapur „	63 D/6	163
Itwa „	63 D/5	162
Ken R., iron	63 D/1	252
Kodaia, diamond	63 D/1	162
Majgama „	63 D/2	162
Maraia „	63 D/2	162
Mohra „	63 D/6	163
Panna „	63 D/2	162
Ranj R. „	63 D/5	162
Sakeriya „	63 D/6	163
Singhpur „	63 D/9	163
Tindini „	63 D/6	163
Udesma (Maharajpur) diamond	63 D/6	163
Patarkechar—		
Banari, diamond	63 D/9	162
Majgawan „	63 D/13	162
Rewah, fluor-spar	..	149
Amarkantak, bauxite	64 F/14	22
Amdari, fire-clay	64 A/11	148
Amha, sandstone	64 A/15	44
Amlia, coal	63 L/8	93
Bardghatta, mica	64 I/9	367
Bardi, copper	63 L/6	124
Bargaon, coal	64 E/12	93

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	Sheet.	Page.
CENTRAL INDIA AGENCY—*contd.*		
Rewah—*contd.*		
Barhwa hill, lithographic stone	63 H/6	311
Baroudi, fire-clay	64 A/10	148
Bhalmuri, coal	64 I/4	93
Bharra, barytes	63 L/7	18
Bodri, limestone	64 E/8	44
Chandia, fire-clay	64 A/10	148
Cherka, copper	63 H/8	124
Ginga hill, barytes	——	18
Jawala Mukhi, coal	64 A/14	92
Jhapi, limestone	64 A/11	44
Johilla R., coal	64 E/3	92
Kalesar, limestone	64 A/14	44
Karimati ,,	64 A/15	44
Khairahi, iron	63 L/12	252
Kirintal, sandstone	64 A/15	44
Korar, coal	64 A/14	92
Kota ,,	63 L/12	93
Majgama, limestone	64 A/14	44
Nandnah, coal	64 E/7	93
Nawa Nagar ,,	63 L/12	93
Padri ,,	63 L/8	93
Pali ,,	64 E/3	92
Pipra, corundum	64 I/9	139
,, jade	,,	282
Sabo, coal	64 E/12	93
Satna, gypsum	63 D/14	227

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	Sheet.	Page.
CENTRAL INDIA AGENCY—*contd*		
Rewah—*contd.*		
Satna, limestone	63 D/14	43
Sohagi Ghat, barytes	63 H/9	18
Sohagpur, coal	64 E/7	93
Son R., iron	63	252
Tagwa, copper	63 H/15	124
Tipan R., coal	64 E/12	93
Umaria, coal	64 A/14	94
„ fire-clay	„	148
„ kaolin	„	287
Urgarhi (Bargawa), silver-lead	63 L/8	298
CENTRAL PROVINCES—		
Akola—		
Purna R., salt	55 H	438
Amraoti—		
Ellichpur, sandstone	55 G/11	44
Balaghat—		
Arjoni, manganese	55 O/13	329
Bakoda „	64 C/1	329
Balaghat „	64 C/1	330
Ballarpur „	64 C/1	329
Bamni, mica	64 B/12	367
Bhui Hurki, manganese	55 O/13	329
Biahtekor „	64 C/1	329
Bodraghat „	64 B/12	330
Botajhari „	55 O/13	329

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	Sheet.	Page.
CENTRAL PROVINCES—*contd.*		
Balaghat—*contd.*		
Budbuda, manganese	55 O/13	329
Chandadoh ,,	55 O/10	328
Chaukhandi ,,	55 O/14	329
Chibarghat ,,	55 O/13	329
Chikmara ,,	55 O/14	329
Chitadongri, mica	64 B/8	367
Dharampur, manganese	64 C/9	330
Dharpiwara ,,	64 C/1	330
Ghondi ,,	64 C/5	330
Gola Hurki ,,	——	329
Jairasi ,,	64 B/16	330
Kanaridha ,,	64 C/9	330
Katanjheri ,,	55 O/13	329
Kochawahi ,,	55 O/13	329
Kothi Pat, bauxite	64 C/5	22
Kurthitola, manganese	64 C/5	330
Lanji, gold	64 C/10	204
Laugur, manganese	64 C/5	330
Malanjkhandi, copper	64 B/12	124
Mau, gold	64 B/4	204
Naudgaon, manganese	55 O/13	329
Nandhi ,,	55 O/14	329
Netra ,,	64 C/1	329
Panchera, gold	64 C/1	204
Parsatola, manganese	64 B/16	330
Ramrama ,,	55 O/13	329

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	Sheet.	Page.
CENTRAL PROVINCES—*contd.*		
Balaghat—*contd.*		
Rupjhar, bauxite	64 C/5	21
Salitikri hills, ochre	64 C/13	394
Samnapur, bauxite	64 C/5	21
Saonri, manganese	55 O/14	329
Sirpur „	55 O/13	329
Sonegaon „	55 O/14	328
Sukeindan, ochre	——	394
Thirori, manganese	55 O/10	328
Tipagarh, bauxite	64 B/8	22
Ukua, manganese	64 C/5	330
Bastar—		
Baordhig R., (Jungani), mica	65 E/9	367
Bharamgarh, gold	65 A/11	204
Hurteli, iron	65 E/1	254
Kolar, gold	65 E/1	204
Partabpur „	65 A/9	204
Topal, iron	64 H/4	254
Betul—		
Bakar, limestone	55 J/4	44
Bhura R., coal	55 F/15	94
Enkawari, limestone	55 J/4	44
Mardanpur, coal	55 F/16	94
Pathé, sandstone	55 F/16	44
Shapur, coal	55 F/16	94
Sonada „	55 F/15	94
Tawa R., „	55 J/4	94

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	Sheet.	Page.
CENTRAL PROVINCES—*contd.*		
Bhandara—		
Ambagarh, gold	55 O/11	204
Asalpani, manganese	55 O/11	333
Biroli, potstone	55 O/15	460
Chikhla I, manganese	55 O/10	332
Chikhla II ,,	55 O/14	332
Dini, potstone	64 C/2	460
Hatora, manganese	55 O/14	331
Kaneri, steatite	64 C/4	460
Karli, manganese	55 O/10	333
Kosumbah ,,	55 O/10	331
Kurmura ,,	55 O/10	332
Miragpur ,,	55 O/14	331
Mohugaon Ghat ,,	55 O/14	332
Pachara ,,	55 O/15	333
Pandarwani ,,	55 O/14	332
Salebaddi ,,	55 O/14	332
Sitapathur ,,	55 O/10	331
Sitasaongi ,,	55 O/10	332
Sukli ,,	55 O/10	331
Tirora, gold	55 O/15	204
Tumkhera Khurd, asbestos	64 C/3	16
Bilaspur—		
Damhamunda, coal	64 J/5	102
Gorakona (Kamrakhol), manganese	64 F/7	333
Hasdo R., coal	64 J	95
Komochoki, mica	64 J/2	367

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	Sheet.	Page.
CENTRAL PROVINCES—*contd.*		
Bilaspur—*contd.*		
Korba, coal	64 J/11	95
Padampur, lead	64 O/10	299
,, limestone	,,	32
Ratanpur, manganese	64 J/3	333
Sendurgar, coal	64 J/5	102
Sonakhan, gold	64 K/11	204
Sumedha, coal	64 J/11	95
Buldana—		
Lonar, salt	56 A/9	438
,, soda	,,	186, 453
Chanda, ochre	..	394
,, salt	..	439
Aliwahi, iron	55 P/11	254
Asola ,,	55 P/16	254
Ballarpur, coal	56 M/5	95
Bandar, coal	55 P/6	96
Bhutara hill, sandstone	55 P/3	44
Bissi, iron	55 P/6	254
Chamoursi ,,	56 M/13	254
Chanda, coal	56 M/5	96
Dewalgaon, iron	55 P/15	254
Emagarh ,,	65 A/6	255
Ghughus, coal	56 M/1	96
Gunjwahi, iron	55 P/16	254
Isapur, sandstone	56 M/5	45
Jambal Ghat, potstone	55 P/6	460

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	Sheet.	Page.
CENTRAL PROVINCES.—*contd.*		
Chanda—*contd.*		
Kandara, limestone	55 L/15	44
Karamgohan ,,	55 L/16	44
Khandeshwar hill, iron	55 P/15	254
Lohara ,,	55 P/11	254
Pipalgaon ,,	55 P/6	255
Poser ,,	65 A/1	255
Ratnapur ,,	55 P/11	255
Telwasa, coal	55 P/4	96
Thana Wasa, copper	56 M/9	124
Wairagarh, diamond	64 D/3	163
Warora, coal	55 P/4	97
,, fire-clay	,,	148
Wingnur, iron	65 A/1	255
Yemlapali ,,	56 M/16	255
Chhindwara—		
Alesur, manganese	55 K/14	335
Anhoni, mineral water	55 J/10	282
Barkoi, coal	55 J/12	98
Bichua, manganese	55 K/14	335
Chandametta, coal	55 J/12	98
Datla ,,	55 J/12	98
Devi, manganese	55 K/14	335
Dudhara, manganese	55 K/14	335
,, rose quartz	,,	176
Gaimukh, manganese	55 K/13	334
Ghoti ,,	55 K/14	335

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CENTRAL PROVINCES—*contd.*		
Chhindwara—*contd.*		
Gowari Warhona manganese	55 K/14	335
Hingladevi, coal	55 J/12	98
Kachi Dhana, manganese	55 K/14	334
Kanhan R., coal	55 J/12	98
Khairi, rose quartz	55 K/14	176
Lakhanwara, manganese	55 K/13	334
Pench R., coal	55 J/12	97
Sirgora, coal	55 J/16	98
„ sandstone	„	44
Sitapar, manganese	55 K/14	334
Tawa R., coal	55 J/8	98
Wagora, manganese	55 K/14	335
Damoh—		
Hatta, lithographic stone	54 P/12	311
Drug—		
Basantapur, iron	64 C/14	256
Borla „	64 C/15	256
Chicholi, copper	64 C/12	124
„ fluor-spar	„	149
„ silver-lead	„	299
Chutrala, iron	64 C/14	256
Dhalli Rajhara, iron	64 H/2	256
Gandai, ochre	64 G/2	394
Jurlakhar, iron	64 C/10	256
Katulkassa „	64 C/11	256
Kumi, iron	64 C/14	256

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	Sheet.	Page.
CENTRAL PROVINCES—*contd.*		
Drug—*contd.*		
Magarkund, iron	——	256
Thakurtola, ochre	64 C/14	394
Worar, copper	64 C/16	125
„ iron	„	256
Hoshangabad—		
Anhoni Samoni, mineral water	55 J/6	382
Chirakhan, sandstone	55 B/15	45
Hoshangabad, flag-stone	55 F/9	45
Joga, silver-lead	55 B/15	299
Kajberi, iron	55 B/15	260
Lokartalai, coal	55 F/7	94
Nimkhera (Lemekhaira), iron	55 B/15	260
Sontalai, iron	55 B/15	260
„ manganese	„	336
Jashpur—		
Pharsabahal, gold	64 N/14	204
Jubbulpore—		
Agaria, iron	64 A/3	257
Bhatadon, manganese	64 A/3	337
Bijeeragogarh, bauxite	64 A/9	21
Bijori, iron	64 A/5	257
Darshani, manganese	64 A/2	337
Dharampur, iron	64 A/3	258
„ manganese	„	338
Ghogra, iron	64 A/3	258
„ manganese	„	337

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	Sheet.	Page.
CENTRAL PROVINCES.—*contd.*		
Jubbulpore—*contd.*		
Gosalpur, iron	64 A/3	258
„ manganese	„	337
Gowari, steatite	55 M/16	461
Imalia, iron	64 A/5	258
Jauli, iron	64 A/3	258
„ ochre	„	394
Jubbulpore, fire-clay	55 M/16	148
„ kaolin	„	287
Kanhwara hills, iron	64 A/5	258
Kasai hill, manganese	64 A/2	337
Katni, bauxite	64 A/5	21
„ fullers' earth	„	150
„ iron	„	257
„ limestone	„	45
Lalpur, steatite	55 M/16	461
Lameta Ghat, coal	55 M/16	98
Lora hill, iron	64 A/3	258
Mansakra, manganese	64 A/3	337
Marble Rocks, agate	55 M/16	152
„ „ amethyst	„	155
„ „ marble	„	45
„ „ steatite	„	461
Murwara, bauxite	64 A/5	23
Nonsar, manganese	55 M/16	338
Sakri „	64 A/3	337
Saroli, ron	64 A/3	258

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	Sheet.	Page.
CENTRAL PROVINCES—*contd.*		
Jubbulpore—*contd.*		
Sihora, iron	64 A/3	257
Silondi ,,	64 A/3	259
Sleemanabad, barytes	64 A/6	18
,, copper	,,	125
,, fluor-spar	,,	149
,, gold	,,	204
,, silver-lead	,,	299
Korea—		
Hasdo R., coal	64 I	99
Jhagrakhand ,,	64 I/4	99
Koreagarh ,,	64 I/8	99
Kurasia ,,	64 I/8	99
Sankat ,,	64 I/11	99
Mandla—		
Banjar R., gold	64 B/7	205
Nagpur—		
Agargaon, tungsten	55 O/8	487
Beldongri, manganese	55 O/7	342
Bhandarbori ,,	55 O/7	344
Borda ,,	55 O/7	341
Dumri Kalan ,,	55 O/3	341
Ghogara ,,	55 O/3	345
Guguldoho, manganese	55 O/7	344
Gumgaon ,,	55 K/15	339
Junapani ,,	55 O/7	345
Kacharwahi ,,	55 O/7	343

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	Sheet.	Page.
CENTRAL PROVINCES—*contd.*		
Nagpur—*contd.*		
Kalmeshwar, ochre	55 K/16	395
Kandri, manganese	55 O/7	340
„ opal	„	175
Khandala, manganese	55 O/7	343
Khorari, limestone	55 O/4	45
Kodegaon, manganese	55 K/15	339
„ opal	„	175
Lohdongri, manganese	55 O/7	342
Mandri „	55 O/7	343
Mandvi Bir „	55 O/3	345
Manegaon „	55 O/7	344
Mansar „	55 O/7	340
Mohugaon „	55 O/3	344
Nagardhan „	55 O/7	342
Nandapuri „	55 O/7	342
Nandgondi „	55 O/2	340
Nima (Nimbha), lead	55 O/3	299
Pali, manganese	55 O/3	345
Panchala „	55 O/7	343
Parsioni „	55 O/3	341
Parsoda „	55 O/7	341
Rajkota „	55 O/7	345
Ramdongri „	55 O/3	339
Risara „	55 K/15	340
Satak „	55 O/7	341
Silewada, sandstone	55 O/3	45

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CENTRAL PROVINCES—*contd.*		
Nagpur—*contd.*		
Sitabaldi hill, basalt	55 O/4	45
Sitagondi, manganese	55 O/3	340
Waregaon ,,	55 O/7	343
Narsinghpur—		
Birmanghat, copper	55 M/4	125
Omarpani, iron	55 I/16	259
Mohpani, coal	55 J/14	100
Tendukhera, iron	55 I/16	259
Nimar—		
Akhund, sandstone	55 B/4	46
Basnia, iron	55 B/12	260
Billora ,,	55 B/4	260
Chandgarh, iron	55 B/11	260
,, manganese	,,	345
Gohugaon, manganese	55 B/12	346
Jamdihi R. ,,	55 B/11	346
Khudia, iron	55 B/12	260
,, limestone	,,	45
Kotra, iron	55 B/12	260
Matni ,,	55 B/11	260
Mohla ,,	55 B/11	260
Nandana ,,	55 B/11	260
Raigarh—		
Ib R., coal	64 O/13	101
Kodaloi, iron	64 O/13	260
Rampur, coal	64 O/13	100

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CENTRAL PROVINCES—*contd.*		
Raipur, lithographic stone		311
„ sandstone		46
Bhatagaon, lignite	64 G/12	307
Ghugwa „	64 G/12	307
Jumrao „	64 G/12	307
Murkatola, pottery clay	64 H/11	287
Rajoo (Rajim), gold	64 H/13	205
Sarguja, bauxite		21
Bansar, coal	64 M/8	102
Bhelaunda, silver-lead	64 M/5	300
Bisrampur, coal	64 M/4	101
Chiraikund, lead	64 I/13	300
Jhilmilli, coal	64 I/15	98
Kutkona „	64 M/4	102
Lakhanpur „	64 N/1	102
Mahan R. „	64 M/3	101
Manpur „	64 M/6	102
Massan R. „	——	101
Morne R. „	64 M/6	102
Panchbhaini „	64 I/16	102
Parsa „	64 J/13	102
Pasang R. „	64 M/4	101
Ramkola „	64 I/14	102
Rampur	64 J/13	102
Rer R. „	64 I/16	101
Tatapani „	64 M/10	102
„ mineral water	„	382

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CENTRAL PROVINCES.—*contd.*		
Saugor —		
Hirapur, iron	54 P/3	260
Seoni—		
Amagarh, bauxite	55 N/12	23
Atarwani ,,	55 O/9	23
Chichuldoh, manganese	55 O/9	346
Dhobitola ,,	55 O/10	346
Khirki ,,	55 O/10	346
Pachdar, gold	55 O/6	205
Udaipur—		
Bakaruma, gold	64 N/6	205
Dharamjaigarh (Rabkhob), gold	64 N/3	205
Jamargi, gold	64 N/11	205
Kamhar, gold	64 N/2	205
Mand R., coal	64 N	102
,, ,, gold		205
Salkao, gold	64 N/2	205
Wardha—		
Paunar, soda	55 L/9	382
Yeotmal—		
Khair, mineral water	56 I/13	382
Malagarh hill, manganese	56 M/1	346
Pisgaon, coal	55 L/16	103
Wun, coal	55 L/16	103
,, potstone	,,	461
Yanak hill, iron	56 M/1	260

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GOA, iron	..	247
Bicholim, manganese	48 E/14	347
Kandiapar ,,	48 I/3	347
Korqui (Kudkee) ,,	48 I/2	347
Kurado ,,	48 I/3	347
Malan ,,	48 I/3	347
Malpona ,,	48 I/3	347
Morlem ,,	48 I/2	347
Mormugao, alum	48 E/15	5
Peritem, manganese	48 I/4	347
HYDERABAD, fullers' earth	..	150
,, soda	..	435
Adilaba :—		
Aksapali, coal	56 M/12	104
Aksapur ,,	56 M/7	103
Antargaon ,,	56 M/10	103
Chinur ,,	56 N/13	103
Dimdurti (Demathoorty), iron	56 I/12	261
Khairgura, coal	56 M/8	104
Kota ,,	56 N/13	103
Sandrapali ,,	56 N/13	103
Sasti ,,	56 M/5	104
Tandur ,,	56 M/8	104
Atraf-i-Balda—		
Hyderabad, amethyst	56 K/7	155
,, opal	,,	175

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HYDERABAD—*contd.*		
Bidar—		
Bidar, laterite	56 G/9	46
Boghiri, iron	——	261
Hulfergah (? Hulburga), manganese	56 G/5	347
Kaliani, iron	56 C/13	261
Marli „	——	261
Gulbarga—		
Baichubal, salt	56 D/10	439
Bhima R., granitoid gneiss	56 H/2	46
Channur, limestone	56 D/11	35
Gagulu, granitoid gneiss	56 H/3	46
Mudanur, mineral water	56 D/6	382
„ pyrites	„	473
Shorapur, lithographic stone	56 D/14	311
Uguni, limestone	56 D/6	35
Wujul, mineral water	56 D/11	382
Karimnagar—		
Maitpalli, potstone	——	461
Sirsilla „	56 J/15	461
Yenchapali (Enchinpilli), antimony	65 B/6	12
Nalgunda—		
Kistna R., limestone	56 P	46
Nalgonda, copper	56 O/8	125
Nizamabad—		
Konasamudram, fire-clay	56 J/10	149
„ iron	„	261

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HYDERABAD—*contd.*		
Nizamabad—*contd.*		
Kondapur, iron	56 J/6	261
Mirtapalli ,,	——	261
Raichur—		
Gajendragarh, syenite	48 M/14	46
Gobur, granitoid gneiss	56 H/3	46
Gutt Bichal, diorite	57 E/5	46
Hanamsagar, sandstone	57 A/1	47
Hutti, gold	56 D/12	205
Jaldrug, granitoid gneiss	56 D/7	46
Jiaddigudd hills, iron	57 A/5	262
Mosulakal, syenite	56 H/3	46
Topuldodi, gold	56 D/16	205
Wondalli ,,	56 D/12	205
Warangal—		
Alapalli, coal	65 C/5	104
Baiora (Buga), mineral water	65 C/9	383
Bandalla, coal	65 B/8	104
Banjur, corundum	65 C/7	139
Chandragunda, coal	65 C/11	104
Damenapilli, potstone	56 O/9	461
Gharibpet, garnet	65 C/11	170
,, kyanite	,,	174
Gobuguru, corundum	65 C/7	139
Golaguda ,,	65 C/7	139
Gudalur, gold	65 B/11	206
Kamaram, coal	65 B/8	104

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	Sheet.	Page.
HYDERABAD—*contd.*		
Warangal—*contd.*		
Kannigiri, coal	65 C/11	104
,, corundum	,,	139
Kinarsani R., gold	65 C/14	206
Lingalla, coal	65 B/16	104
Madavaram ,,	65 G/3	104
Pedda Gopatti, iron	65 C/8	262
Singareni, coal	65 C/6	105
,, iron	,,	262
Warangal, rose quartz	56 O/9	176
Yelgurrup, copper	——	125
KASHMIR—		
Baltistan—		
Askoli (Chongo), mineral water	43 M/14	383
Basha R., gold	43 M/6	206
Bisil (Behitsil), mineral water	43 M/5	383
,, sulphur	,,	473
Chutran, mineral water	43 M/6	383
Duchin (Dushkin), mineral water	43 I/15	383
,, ,, sulphur	,,	473
Kapalu, gold	52 A/8	206
Khorkan, mineral water	52 A/15	383
,, sulphur	,,	473
Rondu, copper	43 M/2	125
Tosha, mineral water	43 M/10	383
Changchengmo—		
Gokra, mineral water	52 J/15	383

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	Sheet.	Page.
KASHMIR—*contd.*		
Dras—		
Kharbu, gold	43 N/14	206
Jammu—		
Dandli, coal	43 G/14	105
Kalakot „	43 K/8	105
Ladda „	43 O/4	106
Lodhra „	43 O/4	106
Mehowgala „	43 K/8	106
Sangar Marg, coal	43 K/12	106
„ „ iron	„	263
Siro valley, coal	43 K/8	107
Kashmir, marble	..	47
„ peat	..	396
Harpat Nag, copper	43 O/5	125
Islamabad, mineral water	43 O/2	383
Kothair, iron	43 O/6	262
Pampur, mineral water	43 J/16	383
Soap (Sof), iron	43 O/6	262
Srinagar, basalt	43 J/16	47
Ladakh—		
Achinathang, gold	52 B/10	206
Kio (Skio) „	52 G/5	206
Knarung, mineral water	52 F/8	383
Nubar—		
Chusan (Panamik), mineral water	52 F/9	384
Padar—		
Barali, arsenic	52 C/3	15

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	Sheet.	Page.
KASHMIR—*contd.*		
Padar—*contd.*		
Machel, beryl	52 C/6	156
Soomjam, sapphire	52 C/6	181
„ tourmaline	„	184
Rudok—		
Kyango Traggar, agate	52 N/7	155
Rupshu—		
Chagya Samdo, gold	52 L/11	206
Puga, borax	52 K/8	24
„ mineral water	„	384
„ sulphur	„	473
Zangskar—		
Yelchung, copper	52 C/13	126
KHORASAN—		
Nishapur, turquoise	..	185
MADRAS—		
Anantapur, fullers' earth	..	150
Atmakur, corundum	57 F/6	140
Bellagupa, saltpetre	57 F/2	450
Danduvarapalli, corundum	57 F/10	140
Maddalcheruvu Sivapuram, corundum	57 F/7	140
Manirevu	57 F/6	140
Motalachintarpalli	——	140
Narjampalli, steatite	57 J/2	461
Nutimadugu, corundum	57 F/7	140
Obalapuram „	57 F/6	140

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	Sheet.	Page.
MADRAS—*contd.*		
Anantapur—*contd.*		
Palavenkatapuram, corundum	57 F/6	140
Paramatiyelaru „	57 F/6	140
Pasalur „	57 F/10	140
Punighi „	—	140
Ramgiri, gold	57 F/7	207
Reddipalli, corundum	57 F/10	140
„ potstone	„	461
Siddarampuram, corundum	—	140
Thimmapuram „	57 F/6	140
Wajra Karur, diamond	57 E/8	163
Arcot (North), building stone	..	48
Gudyatam, iron	57 L/13	265
Pathur, steatite	57 O/4	461
Paupantangalam, kaolin	57 P/5	288
Polur, iron	57 P/2	263
Sannamalai, iron	—	263
Tilavaram, ochre	57 O/11	395
Vellore, iron	57 P/1	265
Arcot (South), iron	..	263
„ „ salt	..	439
Chinna Tirupadi, iron	58 I/14	265
Madur hill, iron	58 I/9	265
Panroti, pottery clay	58 M/9	288
Porto Novo, iron	58 M/15	265
Sankaraparam, iron	58 I/13	265

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	Sheet.	Page.
MADRAS—*contd,*		
Arcot (South)—*contd.*		
Semangalam, kaolin	57 P/12	288
Tirnavalour (Tiruvananalur), jade-stone	58 M/5	48, 283
Tiruvannamalai, iron	57 P/4	265
Trivandipuram, ochre	58 M/10	395
Vellumpalaiyam, sandstone	58 M/5	48
Velur, sandstone	58 M/5	48
Wodiapolliam, sulphur	58 M/6	474
Bellary, iron	..	263
Angur, potstone	48 N/13	49,462
Arsapur hill, potstone	57 B/2	462
Copper Mt. copper	57 A/16	126
Dammur, granite	57 A/15	48
Daroji, magnesite	57 A/11	312
Harappanahalli, copper	48 N/13	126
„ potstone	„	49, 462
Hurlihall, porphyry	57 B/10	48
Huvina Hadagalli, diamond	48 M/16	164
„ „ limestone	„	49
Jajkul Gudda, gold	57 B/1	207
Kallakurti, prophyry	57 F/1	49
Kapgal hill, granite	57 A/16	48
Kurikuppa (Koreekoompa) hill, porphyry	57 A/12	48
Mallapan Gudda, iron	48 N/13	265
Metra, green quartzite	57 A/11	49
Nemkal „ „	57 A/16	49
Nilgunda hill, potstone	48 N/14	49, 462

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	Sheet.	Page.
MADRAS—*contd.*		
Bellary—*contd.*		
Siddapan Konda, copper	57 E/2	126
Somalapuram, steatite	57 A/12	462
Tallur, limestone	57 A/12	49
Teligi hill, manganese	48 N/14	348
Tornagal hill, porphyry	57 A/12	48
Ubbalagandi, jasper	57 A/12	49
(**Sandur**)—		
Adargani, ochre	57 A/12	395
Ettinahalli (Yettunhally), jasper	57 A/12	49
Kammat Haruvu, iron	57 A/12	265
„ „ manganese	„	349
Kannevihalli, iron	57 A/12	265
Ramandrug, antimony	57 A/8	12
„ manganese	„	349
„ mineral water	„	384
Timappagarh (Timangarh), jasper	57 A/12	49
Chingleput, iron	...	263
Attrampakkam R., pottery clay	57 O/16	288
Chingleput, iron	57 P/14	265
Conjeveram, sandstone	57 P/9	49
Coopum, pottery clay	66 C/4	288
Cuddapary Choultry, gneiss	66 D/1	49
Kathiwakam (Ennur), gypsum	66 C/8	227
Monegur Choultry „	66 C/8	227
Nundiveram, granitoid gneiss	66 D/1	49
Palaveram, hornblendic gneiss	66 D/1	49

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	Sheet.	Page.
MADRAS—*contd.*		
Chingleput—*contd.*		
Puttandalum, hornblendic gneiss	66 D/1	49
Red Hills, manganese	66 C/4	350
Sattavedu, sandstone	57 O/15	49
Seven Pagodas, granitoid gneiss	66 D/2	49
Sirgulpilli, sandstone	——	49
Sripermatur (Sriperumbudur), pottery clay	57 P/13	288
Tirukarikunum, granitoid gneiss	66 D/2	49
Wallajabad, hornblendic gneiss	57 P/13	49
Coimbatore—		
Bensibetta, gold	58 E/6	207
Coimbatore, saltpetre	58 B/13	450
Edamaranahalli, steatite	57 H/8	462
Gopichettipalaiyam, corundum	58 E/7	140
Hadabanatta (Adapullnatta), copper	58 E/5	126
„ „ gold	„	207
Kandyankovil, corundum	58 E/8	140
Kangayam, chrysoberyl	58 F/9	157
„ corundum	„	140
„ zircon	„	185
Kanjikovil, kyanite	58 E/11	174
Karutapalaiyam, corundum	58 E/12	140
„ mica	58 E/12	367
Kavudahalli, gold	57 H/8	207
Kollegal Taluk, iron	57 H	265
Madukarai, marble	58 B/13	49
Padyur (Pattalai), aquamarine	58 E/8	156

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	Sheet.	Page.
MADRAS—*contd.*		
Coimbatore—*contd.*		
Padyur (Pattalai), corundum	58 E/8	141
,, ,, mica	,,	367
Palghat, iron	58 B/9	263
Perandurai, asbestos	58 E/11	16
Porsegaundapalaiyam, gold	58 E/5	207
Satyamangalam Taluk, iron	58 E	265
Selangapalaiyam, corundum	58 E/11	141
Shigrispalaiyam, corundum	58 E/7	141
Virapaneli (?Virapandi), manganese	58 A/16	350
Coorg—		
Fraserpet, magnesite	48 P/15	312
Pollibetta, mica	48 P/16	368
Seringala, magnesite	48 P/11	312
Cuddapah, slate	..	50
Chennur, diamond	57 J/14	164
Gandikot, soda	57 J/5	455
Gurapur, diamond	57 J/14	165
Hussanapur (Dupaud), diamond	——	165
Jamaladugu (Gulagunta) ,,	57 J/5	165
Jangamrajpilli, antimony	57 J/13	12
,, copper	,,	126
,, silver-lead	,,	300
Kanuparti (Kondapetta), diamond	57 J/14	164
Kotelur (? Kottur), lead	57 J/10	300
Lamdur, diamond	——	165
Lankamalai, lead	57 J/14	300

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	Sheet.	Page.
MADRAS—*contd.*		
Cuddapah—*contd.*		
Magasanipilli, lead	57 J/14	300
Nerji, limestone	57 J/10	50
Ovalampalli (Woblapalli), diamond	57 J/14	165
Pinchetgapadu, diamond	——	165
Ramiapullem, iron	——	263
Yeraguntlakota, iron	57 O/5	266
Ganjam, salt	..	439
Bodiamba, mica	74 A/9	368
Boirani, manganese	74 A/14	350
„ opal	74 A/14	176
Goradandi, mica	74 A/9	368
Gudhiari, manganese	74 A/14	350
Guma hills, mica	74 B/1	368
Gumsur, iron	74 A/9	263
Jillundi, mica	74 A/9	368
Kalikot, manganese	74 E/2	350
Nautan-Barampur, manganese	74 E/2	350
Rambha, manganese	74 E/2	350
Rayagada hills, mica	——	368
Sisunda, mica	73 D/12	368
Godavari, iron	..	263
Beddadanol, coal	65 G/4	107
Bhadrachalam, diamond	65 C/14	165
Gondala, mineral water	65 C/14	384
Kunnavaram, molybdenum	65 G/6	389
Peddapuram, sandstone	65 K/4	50

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	Sheet.	Page.
MADRAS—*contd.*		
Godavari—*contd.*		
Perakonda, graphite	65 G/6	221
Polavaram, iron	65 G/12	266
Rajahzompalli, coal	65 G/6	105
Rajamahendri, agate	65 G/16	155
„ kaolin	„	288
„ rock crystal	„	176
Surisanianam, sulphur	65 L/3	474
Guntur, iron	..	263
Amaravati, limestone	65 D/6	50
Bellamkonda, saltpetre	65 D/2	450
Chebrolu, sandstone	65 D/12	50
Chintapilli, lithographic stone	65 D/2	311
Dachapilli „ „	56 P/10	311
Gantlapalem (Agnigundala), copper	56 P/12	127
Karampudi, lead	56 P/11	301
Kollur, diamond	65 D/2	165
Kondavidu hills, granitoid gneiss	65 D/7	50
Madagula, diamond	56 P/10	166
Malavaram (Damarapad), diamond	56 P/6	166
Pavulur, sandstone	66 A/1	50
Pulichinta, diamond	65 D/2	166
Tangellamudi, sandstone	65 D/11	50
Kistna, iron	..	263
Atkur, diamond	65 D/6	167
Barthenipadu, diamond	65 D/6	167
Bezwada, garnet	65 D/10	171
„ graphite	„	221

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	Sheet.	Page.
MADRAS—*contd.*		
Kistna—*contd.*		
Golapilli, diamond	65 D/14	166
Jaggayapetta (Batavole), lithographic stone	65 D/1	311
Janampet, sandstone	65 H/1	50
Kodavatakallu, diamond	65 D/2	167
Komera, iron	65 H/5	266
Kondapilli, garnet	65 D/10	171
„ lithographic stone	„	311
Latchmipuram, iron	65 G/8	266
Malavilli (Muleli), diamond	65 D/14	166
Mugalur, diamond	65 D/6	167
Munalur, diamond	65 D/6	167
Partial, diamond	65 D/6	167
Peddavegi, sandstone	65 H/1	50
Pentlam, iron	65 H/5	266
Ramakapeta, iron	65 D/13	266
Tundkalpudi, sandstone	65 H/1	50
Ustapalli, diamond	65 D/2	167
Kurnool, iron	..	263
Ambapuram, steatite	57 I/3	463
Balapalapalli, steatite	57 I/3	463
Banganapalle, diamond	57 I/3	168
„ manganese	„	351
Bannur, diamond	57 I/2	168
Baswapur (Basavapuram), cerium	57 I/11	429
„ „ diamond	„	168
„ „ silver-lead	„	301

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	Sheet.	Page.
MADRAS—*contd.*		
Kurnool—*contd.*		
Baswapur (Basavapuram) zinc	57 I/11	489
Byanpalli, diamond	57 I/2	169
Chandrapalli, barytes	57 E/16	19
Coomroli, diamond	57 I/2	169
Deomurru, diamond	57 I/1	169
Devanur, diamond	57 I/6	169
Dhoni, diamond	57 E/15	169
„ steatite	„	462
Gani, copper	57 I/6	127
Gazerpilli (Gazulapalli), barytes	57 I/11	19
„ „ diamond	„	169
Gudipaud, diamond	57 I/2	169
Gujjalakonda, copper	57 M/5	127
Gumankonda, copper	57 I/6	127
Gunigal, iron	57 I/2	266
Gurumankonda (Gottimanikonda), diamond	57 I/2	169
Jaladurgam, barytes	57 E/15	19
Kadrabad, marble	57 I/1	51
Kalva, mineral water	57 I/2	384
Kannamadakalu, diamond	57 I/2	169
Khundair R., limestone	57 I/8	50
Koilkuntla, silver-lead	57 I/8	301
Kommemarri, copper	57 E/16	127
Kurnool, marble	57 I/1	51
Lanjabanda, mineral water	57 I/3	384
Lanjapolur, diamond	57 I/1	169

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MADRAS—*contd.*		
Kurnool—*contd.*		
Madavaram, diamond	57 I/3	169
„ magnesite	„	313
„ steatite	„	456, 462
Maddikerai, saltpetre	57 E/8	450
Mahanandi, mineral water	57 I/11	384
Markapur, saltpetre	57 M/6	450
Munimadagu, diamond	57 E/15	169
Muravakonda, diamond	56 L/8	169
Musila Cheruvu, magnesite	57 I/3	313
„ „ steatite	„	462
Nagireddipalli, manganese	57 I/12	351
Nalamalai, iron	——	266
Nandavaram, manganese	57 I/7	351
Oruvakal (Voravakollu), diamond	57 I/2	169
Panchalingala, diamond	57 I/1	169
Pendekallu, steatite	57 E/11	463
Polur, diamond	57 I/6	169
Pyapalli, diamond	57 E/12	169
Ramulkota, diamond	57 I/2	169
Roodrar (Rudravaram), iron	57 I/12	266
„ „ manganese	„	350
Saitankota, diamond	——	170
Somadalpilli (Somayazulapalli), copper	57 I/2	127
Tandrapad, diamond	57 I/1	170
Timapuram, diamond	57 I/2	170
Tungabhadra R., lithographic stone	57 E	311

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MADRAS—*contd.*		
Karnool—*contd.*		
Viraypalle, diamond	——	170
Yembye diamond	57 I/2	170
Madura, iron	..	264
„ saltpetre	..	451
Ambalathandi, granitoid gneiss	58 K/1	51
Arupukotai, granitoid gneiss	58 K/2	51
Fort Hamilton, bauxite	58 F/8	21
Kalligudi, granitoid gneiss	58 G/14	51
Kodaikanal, bauxite	58 F/8	21
Kotaiparai, hornblendic gneiss	58 K/3	51
Manurupur, granitoid gneiss	58 K/2	51
Talakanath, gold	58 F/15	208
Palani (? Palni), ferro-tantalite	58 F/11	430
Puda-kudi, manganese	——	351
Puliarpatti, granitoid gneiss	58 J/12	51
Shayalapatti, granitoid gneiss	58 K/2	51
Sivaganga, sandstone	58 K/5	51
Tirumal, marble	58 K/2	51
Tiruparai-kundram, granitoid gneiss	58 K/1	51
Tirushalai, banded gneiss	58 K/2	51
Veigei R., gold	58 F/16	208
Malabar, iron	..	264
„ laterite	..	51
Beypur, iron	49 M/16	267
„ lignite	„	308
Cannanore, lignite	49 M/5	308

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	Sheet.	Page.
MADRAS—*contd.*		
Malabar—*contd.*		
Cochin, limestone	58 C/1	51
Feruk, iron	49 M/16	267
Manarkad, gold	49 M/15	208
Nemini, iron	58 A/4	267
Nilambar, gold	58 A/3	208
„ iron	„	266
Porur, iron	58 A/8	267
Verkella hill, iron	49 M/15	267
Wandur, iron	58 A/4	267
Yeddakurichi, iron	58 B/9	267
(Wynaad)—		
Cherambadi, mica	58 A/6	368
Devala, gold	58 A/7	209
„ mica	„	368
Gudalur, mica	58 A/7	368
Nellakota, mica	58 A/6	368
Pandalur, gold	58 A/7	209
„ mica	„	368
Nellore, apatite	..	425
„ garnet	..	171
„ manganese	..	351
„ saltpetre	..	451
Atmakur, mica	57 N/10	369
Burapalle, iron	57 M/14	267
Chaganum, columbite	57 N/12	430
Garimanipenta (Ganipenta), copper	57 N/9	127

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	Sheet.	Page.
MADRAS—*contd.*		
Nellore—*contd.*		
Gogulapalli, copper	57 M/7	128
Gudur, mica	57 N/16	369
Inikurti, mica	57 N/11	369
Jogipalli, steatite	57 N/12	463
Kalichedu, mica	57 N/11	369
Kaluvaya, potstone	5 N/6	463
Kavali, mica	57 N/13	369
Konijedu hills, iron	57 M/15	257
Kuchupudi hill, granitoid gneiss	57 M/11	51
Lakshminarayana, mica	57 N/12	369
Maneru R., iron	66 A/4	268
Mangalpur, mica	——	369
Manikesavaram, iron	57 M/13	267
Narravada, barytes	57 N/5	19
Ongole, iron	66 A/2	267
Pallimitta, mica	57 N/1	369
Parnametta hill, iron	66 A/2	267
Polenane Cheruvu, iron	57 M/12	268
Rappala Dibba, mica	——	369
Rapur, mica	57 N/1	369
Saidapuram, potstone	57 N/1	463
Sankara, mica	57 N/15	369
„ samarskite	„	431
Santaravur, gypsum	66 A/5	227
Singarikonda, iron	57 M/13	267
Swarnamukhi R., iron	57 O/13	268

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	Sheet.	Page.
MADRAS—*contd.*		
Nellore—*contd.*		
Tellabodu, mica	57 N/12	369
Udayagiri Taluk, iron	57 N/5	264
Vemparala, iron	57 M/13	267
Nilgiri, gneiss	..	52
„ peat	..	397
Dodabetta, iron	58 A/11	268
„ kaolin	„	288
Jackatalla (Wellington), iron	58 A/15	268
Karachola, iron	58 A/15	268
Kotagiri, iron	58 A/15	264
Moyar R., iron	58 A	264
Ootacamund, bauxite	58 A/11	21
„ manganese	„	351
„ ochre	„	395
Seven Cairns hill, garnet	58 A/11	171
Pudukotai—		
Ayangudi, iron	58 J/15	268
Kunamulla, granitoid gneiss	58 J/14	52
Mallampatti, iron	58 J/10	268
Shahkotai, laterite	58 J/16	52
Shenkarai „	58 J/15	52
Tirkonum, granitoid gneiss	58 J/15	52
Trimiem „ „	58 J/16	52
Virallimalai „ „	58 J/10	52
Ramnad—		
Pantalagudi, limestone	58 K/3	52

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MADRAS—*contd.*		
Ramnad—*contd.*		
Rameswaram, sandstone	58 O/7	52
Valimukkam ,,	58 K/12	52
Salem, asbestos	..	16
,, iron	..	264
,, sulphate of magnesia	..	468
Alangayam, barytes	57 L/14	19
Arasiramani, mica	58 E/14	369
Attur, iron	58 I/10	270
Baramahal, soda	——	455
Chalk hills, chromite	58 I/2	63
,, ,, magnesite	,,	313
Chinnamali, mica	58 E/14	369
Chintalakuttai, corundum	57 L/6	141
Dharmapuri, corundum	57 L/4	141
Donnakuttahalli, corundum	57 H/16	141
Erumaipatti, potstone	58 I/8	463
Ettapur, iron	58 I/6	269
Godamalai, iron	58 I/6	268
Iddapadi, mica	58 E/14	369
Iswaramalai, magnesite	58 I/6	314
Kanavaipatti hill, iron	58 I/4	269
Kanjamalai, cerium	58 I/2	429
,, chromite	,,	64
,, iron	,,	269
,, magnesite	,,	314
Karuppur, chromite	,,	64

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MADRAS—*contd.*		
Salem—*contd.*		
Karuppur, potstone	58 I/2	463
Kirambur, iron	58 I/4	269
Kolimalai, iron	58 I/7	269
Mahanpolliam, limestone	58 E/15	52
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Namagiripetta, iron	58 I/7	270
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Appiyode, zircon	58 H/4	185
Aramboly, graphite	58 H/11	222
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„ graphite	„	222
„ molybdenum	„	389
„ nickel	„	392
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Attungal, graphite	58 D/14	222
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Kolachel, graphite	58 H/8	222
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Chitral, arsenic	..	15
Dera Ismail Khan—		
Paniala, gypsum	38 L/16	228
Saiduwali, gypsum	38 P/4	228

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NORTH-WEST FRONTIER PROVINCE—*contd.*		
Hazara, building materials	..	55
Abbotabad, limestone	43 F/4	55
Bandi Munim, lead	43 G/5	302
Bari-ka-Bugla, gypsum	43 F/8	228
Bijora, gypsum	43 F/8	228
Dore R., coal	43 F/8	107
Dowatta, gypsum	43 F/7	228
Kakal ravine, silver-lead	43 F/7	302
Khagan R., kaolin	43 F	289
Lalo Gali, gold	43 B/15	216
Sirban hill, iron	43 F/4	275
Ugri, lead	43 F/2	302
Kohat, building materials	..	55
Bahadur Khel, gypsum	38 K/16	228
„ „ salt	„	440
Burburra, salt	38 O/3	441
Dhand, coal	38 O/8	108
Gunjalli, sulphur	38 O/15	474
Jatta, salt	38 O/7	441
Kharak, salt	38 O/4	441
Kohat, coal	38 O/6	108
Kurar, salt	38 O/8	441
Luni-ki-kassi, sulphur	38 O/14	474
Malgin, salt	38 O/11	441
Nari, salt	38 O/4	441
Nundrukki, salt	38 O/11	441
Panoba, petroleum	38 O/14	420

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	Sheet.	Page.
NORTH-WEST FRONTIER PROVINCE—*contd.*		
Kohat—*contd.*		
Panoba, sulphur	38 O/14	474
Shin Dhand, coal	38 O/10	108
Sirraikhwa, salt	38 O/4	441
Surdag, celestite	38 K/16	469
Tajut hill (Taghoot Sir), manganese	38 O/2	361
Zaino, salt	38 O/11	441
Zertangi, gold	38 O/11	216
Kurram		
Zaimukht hills, antimony	38 K/10	13
Shirani—		
Domanda, sulphur	39 I/2	474
Moghal Kot, coal	39 I/3	108
„ „ petroleum	„	420
Zor Shahr, gypsum	39 I/2	228
Waziristan—		
Kaniguram, asbestos	38 H/14	17
„ iron	„	275
Miran Shah, iron	38 L/1	275
Pir Karal, coal	38 H/10	108
PONDICHERRY—		
Aranganur, lignite	58 M/9	308
Bahour „	58 M/9	308
Koniakovil, lignite	58 M/13	308
Valudayur, phosphate of lime	58 M/9	425
PUNJAB, saltpetre	..	451

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	Sheet.	Page.
PUNJAB—*contd.*		
Ambala—		
Kalka, lignite	53 B/13	309
Attock—		
Ankur R., gold	43 C/4	216
Borari, petroleum	43 C/10	421
Chak Dalla, petroleum	43 C/6	421
Chharat, petroleum	43 C/10	421
Choi, coal	43 C/2	108
Gabir R., gold	43 C/8	216
Gunda (Sudkal), petroleum	43 C/10	421
Hassan Abdul, limestone	43 C/9	55
Indus R., gold	38 O	216
Jafar, petroleum	43 C/9	422
Khaur, petroleum	43 C/8	421
Makhad, gold	38 O/12	216
Multan gold	43 C/4	216
Naka, gold	43 D/5	216
Sadiali (Sadhewali), petroleum	38 P/14	422
Sohan R., gold	43 C/4	216
Taman, gold	43 C/4	216
Trap, gold	38 O/16	216
Delhi—		
Kasumpur, kaolin	53 H/2	290
Dera Ghazi Khan—		
Gandahari hill, sulphur	39 G/12	475
Sangarh pass, sulphur	39 J/6	475
Sori pass, sulphur	39 J/7	475

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	Sheet.	Page.
PUNJAB—*contd.*		
Dera Ghazi Khan—*contd.*		
Vadur, fullers' earth	39 J/12	151
Gurgaon—		
Aurangpur, rock crystal	53 H/7	177
Bhunsi, mica	53 H/3	371
Firozpur, iron	54 A/13	276
Kund, slate	53 D/8	58
Mahanti, mica	——	371
Nuh, salt	53 H/4	441
Rewari, slate	53 D/12	55
Sohna, gold	53 H/4	216
„ graphite	„	223
„ mineral water	„	385
Sultanpur, salt	53 H/4	441
Hoshiarpur, glass-making materials	..	187
Jhang—		
Kirana hills, iron	44 A/9	276
„ „ manganese	„	361
Hundiwala, pyrrhotite	44 A/9	475
Jhelum, glass-making materials	..	187
Bhaganwala, coal	43 H/2	109
Bunhar R., gold	43 H/5	216
Dandot, alum	43 D/14	6
„ coal	„	109
„ phosphate of lime	„	425
Jalalpur, gypsum	43 H/6	229
Jutana, salt	43 H/2	443

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	Sheet.	Page.
PUNJAB—*contd.*		
Jhelum—*contd.*		
Jutana, sandstone	43 H/12	56
Kahan R., gold	43 H/5	216
Karangli hill, antimony	43 H/2	13
„ „ lead	„	302
Khewra, lead	43 H/2	302
„ potash salts	„	428
„ salt	„	443
„ sulphate of magnesia	„	468
„ sulphate of soda	„	469
Makrach, salt	43 D/14	443
Nurpur, fullers' earth	43 D/10	151
„ potash salts	„	428
„ salt	„	444
Pidh, coal	43 D/14	110
Sardi, gypsum	43 D/14	229
„ marble	„	56
„ salt	„	443
Kangra—		
Bir, iron	52 D/12	276
Dharmasala, iron	52 D/8	276
„ manganese	„	361
Jawala Mukhi, mineral water	53 A/5	385
Kanhiara, slate	52 D/8	56
Kohad, iron	52 D/16	276
Lausa, mineral water	52 D/3	385
Mirthal, gold	43 P/12	217

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	Sheet.	Page.
PUNJAB—*contd.*		
Kangra—*contd.*		
Rai, gold	43 P/16	217
Tatwani, mineral water	52 D/12	385
Tiva (Jiva), mineral water	52 D/4	385
(Kulu)—		
Bajaura, iron	53 E/1	277
Bashisht, mineral water	52 H/3	385
Chisani, copper	53 E/1	129
Chong, silver-lead	53 E/1	303
Hamta pass, mica	52 H/7	371
„ „ sapphire	„	182
Jhari, copper	52 H/4	129
„ silver-lead	„	302
Khanor Khud, silver-lead	52 H/8	302
Khelat-(Sita)-Khund, mineral water	52 H/4	385
Koman, silver-lead	53 E/1	303
Manikarn, mineral water	52 H/8	386
„ silver-lead	„	302
Maol, copper	53 E/1	130
Parbati R., mica	52 H/8	371
Samsi, gold	53 E/1	217
Saond, copper	53 E/1	130
Shatghar copper	53 E/1	130
Uchich, silver-lead	52 H/8	303
(Lahoul)—		
Shigri, antimony	52 H/11	13
„ zinc	„	489

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	Sheet.	Page.
PUNJAB—*contd.*		
Kangra—*contd.*		
(Mandi)—		
Drang, salt	53 A/13	445
Guma, salt	53 A/13	445
Thirri (Sirhi), bismuth	53 E/1	23
„ „ manganese	„	361
(Spiti)—		
Dankhar, lead	52 L/4	303
Dauksa, ochre	52 L/4	396
Gyundi R., gypsum	52 H/15	230
Hanlé Chu, chromite	52 L/14	65
Muth, iron	53 I/1	277
Po, lead	52 L/8	303
Lahore, glass-making materials	..	187
Mianwali—		
Bakh ravine (Namal), lithographic stone	38 P/14	311
„ „ „ mineral water	„	386
Basti Algad, petroleum	38 P/6	422
Chitta Wahan, sulphate of iron	38 P/9	467
Isa Khel, coal	38 P/6	110
Jaba, petroleum	38 P/9	422
„ sulphur	„	475
Kalabagh, alum	38 P/9	6
„ coal	„	110
„ gypsum	„	229
„ lignite	„	309
„ rock crystal	„	177
„ salt	„	445

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	Sheet.	Page.
PUNJAB—*contd.*		
Mianwali—*contd.*		
Kotki, alum	38 P/5	6
Kuch, coal	38 O/12	110
Malla Khel, coal	38 P/1	110
Mari, rock crystal	38 P/9	177
Multan, pottery clay	...	290
Patiala—		
Baliana, quartzitic sandstone	53 D/3	57
Baliari, limestone	54 A/1	56
Begopur, quartzite	54 A/1	57
Biharipur, marble	54 A/1	57
Chhapri, iron	54 A/1	277
Datla hill, marble	53 D/4	56
Dhani Bathanta, limestone	54 A/1	56
Dhanota, iron	53 D/4	277
Dhonkora, marble	54 A/1	57
Gatasher, mica	54 A/1	371
„ rutile	„	432
Goela, manganese	54 A/1	361
„ marble	„	57
Jalanwali, marble	54 A/1	57
Khaspur, quartzitic sandstone	53 D/4	57
Makandapur, marble	54 A/1	57
Mandi hill, marble	53 D/4	56
Mandlana, quartzitic sandstone	53 D/4	57
Motaka, copper	54 A/1	130
Musmuta, mica	54 A/1	371

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	Sheet.	Page.
PUNJAB—*contd.*		
Patiala—*contd.*		
Narnaul, kyanite	53 D/4	174
Panchnauta, mica	54 A/1	371
Pinjaur, mineral water	53 B/13	386
Rajawas, quartzitic sandstone	53 D/3	57
Sarali, mica	54 A/1	371
Sohla, iron	53 D/4	277
Rawalpindi—		
Basala, petroleum	43 C/14	422
Chirpar hill, petroleum	43 C/14	422
Dunga Gali, gypsum	43 F/8	230
Landigar, petroleum	43 C/14	422
Margala pass, sulphur	43 C/14	475
Murree (Clifden), gypsum	43 G/5	230
Nerh hill, lignite	43 G/10	309
Ratta Hotar (Shah-ki-Nurpur), petroleum	43 G/1	423
Sydpur, petroleum	43 G/2	423
Shahpur—		
Amb, alum	38 P/14	6
Chinnur, petroleum	43 D/2	423
Duma, petroleum	43 D/2	423
Hangush, petroleum	43 D/2	423
Jhakar Kot, coal	43 D/6	111
Katha, copper	43 D/6	130
,, marble	,,	56
Sulgi, petroleum	38 P/15	423
Tejuwala, coal	43 D/6	111

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	Sheet.	Page.
PUNJAB—*contd.*		
Shahpur—*contd.*		
Varcha, marble	38 P/15	56
„ salt	„	443
Virgal, alum	43 D/3	6
Simla—		
Chapla, silver-lead	53 F/1	303
Sar, lead	53 F/1	303
Simla, building materials	53 E/4	57
„ diamond	„	170
„ pottery clay	„	290
Solan, copper	53 F/1	130
Subathu, barytes	53 B/13	19
Simla Hill States—		
(Bashahr), kyanite	...	174
Chango pass, gypsum	53 I/9	230
Changrizang, mineral water	52 L/12	386
Jaori, mineral water	53 E/14	386
Lipak R., gypsum	53 I/9	230
Shalkar, gypsum	53 I/9	230
„ sulphate of magnesia	„	468
Shele, iron	53 E/12	276
Sungnam, copper	53 I/5	129
Sutlej R., amethyst	53 I	155
„ gold	„	217
Wangtu Bridge, beryl	53 I/2	156
„ „ fluor-spar	„	149
„ „ mica	„	371

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	Sheet.	Page.
PUNJAB—*contd.*		
Simla Hill States—*contd.*		
(Bhajji)—		
Basantpur, lead	53 E/4	303
Suni, mineral water	53 E/4	386
(Bilaspur)—		
Bhasra, mineral water	53 A/12	386
(Dargoti), lead	...	303
(Suket)—		
Jauri, gold	53 A/15	217
Sirmur—		
Aiyur, silver-lead	53 F/9	304
Chaita, iron	53 F/5	277
Gumti R., gold	53 F/6	217
Lakandi R., iron	—	277
Markhanda R., gold	53 F/2	217
Nahan, iron	53 F/6	277
Silani, lignite	53 F/2	309
RAJPUTANA—		
Ajmer-Merwara, garnet	..	172
„ „ graphite	...	223
Ajmer, copper	45 J/11	130
„ fullers' earth	„	151
„ iron	„	277
„ mica	„	371
Bhinai, mica	45 J/16	371
Ganeshpura, lead	45 J/12	304

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	Sheet.	Page.
RAJPUTANA—*contd.*		
Ajmer-Merwara—*contd.*		
Gugra, copper	45 J/10	130
Kalinjar, mica	45 K/5	371
Kharwa, manganese	45 J/8	362
Kheta Khera, limestone	45 J/8	57
Nagpahar, lapis lazuli	45 J/11	175
Rajauri (Rajosi), copper	45 J/11	130
Rajgarh, copper	45 J/11	130
Rawatmal, mica	45 K/1	371
Srinagar, opal	45 J/15	176
„ quartzite	„	57
Suliakhera, mica	45 K/1	371
Talana, mica	45 J/15	371
Taragarh, barytes	45 J/11	20
„ lead	„	304
Alwar—		
Baghani, copper	——	131
Baldeogarh, marble	54 A/8	57
Berla, quartzite	54 A/16	57
Bhangarh, copper	54 A/8	131
„ iron	„	277
„ manganese	„	362
„ nickel	„	392
Daribo, alum	54 A/8	8
„ copper	„	131
Dhadakir, marble	54 A/10	57
Gudha, lead	54 A/7	304

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	Sheet.	Page.
RAJPUTANA—*contd.*		
Alwar—*contd.*		
Indawas (Jodawas), copper	54 A/7	131
,, ,, silver-lead	,,	304
Jasingpur, copper	54 A/8	131
Jheri, marble	54 A/4	57
Kho, marble	54 A/8	57
Kushalgarh, copper	54 A/7	131
Malakheri, quartzite	54 A/11	58
Mandan, flagstone	53 D/8	58
Motidongri, marble	54 A/10	57
,, rutile	,,	432
Pertabgarh, copper	54 A/4	131
Rajgarh, iron	54 A/12	277
,, flagstone	,,	58
Tasing, copper	54 A/1	131
Banswara—		
Itala, manganese	46 I/7	362
Bharatpur—		
Basawar, copper	54 E/4	131
Bharatpur, salt	54 E/8	446
,, sandstone	,,	58
Dig, salt	54 E/7	446
Kumher, salt	54 E/7	446
Nithahar, copper	54 F/1	131
Rupbas, sandstone	54 F/9	58
Bikaner—		
Bhadasar, copper	44 L/7	131

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	Sheet.	Page.
RAJPUTANA—*contd.*		
Bikaner—*contd.*		
Dulmera, sandstone	44 H/11	58
Lonkara Sar, salt	44 H/11	447
Mar (Meth), fullers' earth	45 A/13	151
Palana, coal	45 E/5	111
„ fullers' earth	„	151
Bundi—		
Bhairompura, iron	45 O/10	278
Datunda, copper	45 O/7	131
„ manganese	„	362
Dholpur—		
Kathumri, gypsum	54 J/2	227
Kesarbagh, manganese	——	326
Dungarpur, apatite	..	426
„ magnesite	..	315
Jaipur, mica	..	371
Amber, flagstone	45 N/13	59
Babai, copper	45 M/13	131
Buchara, kaolin	45 M/14	290
Daraoli, kaolin	54 B/13	290
Dogetha, steatite	54 A/8	465
Garh, copper	54 B/10	132
Gisgarh, steatite	54 B/9	465
Kachor Rewasa, salt	45 M/3	447
Karwar, iron	54 F/2	278
Kawa, steatite	54 B/9	465

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	Sheet.	Page.
RAJPUTANA—*contd.*		
Jaipur—*contd.*		
Khetri, alum	45 M/13	8
„ cobalt	„	113
„ copper	„	132
„ nickel	„	392
„ sulphate of copper	„	466
Lalsot, copper	54 B/6	132
Maundla, marble	——	58
Morra, steatite	54 B/13	465
Nabaro, copper	54 A/8	132
Nimla, iron	54 A/8	278
Raghunathgarh, sandstone	45 M/6	59
Raialo, iron	54 A/4	278
„ marble	„	58
Raipur, iron	45 M/14	278
Rajmahal, beryl	45 O/5	157
„ garnet	„	172
Ramgarh, turquoise	45 M/4	185
Rasnu, kaolin	54 B/10	290
Salimpur, flagstone	54 A/16	58
Sambhar, borax	45 N/1	24
„ salt	„	446, 447
„ sulphate of soda	„	469
Singhana, alum	44 P/16	8
„ copper	„	32
„ sulphate of copper	„	466
Udhala, copper	54 A/8	132

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	Sheet.	Page.
RAJPUTANA—*contd.*		
Jaisalmer—		
Abur, marble	40 I/12	59
Deori Chakardha, lithographic stone	40 I/11	312
Jaisalmer, limestone	40 J/13	59
Mandar, fullers' earth	40 I/15	151
Kishangarh		
Barla, fluor-spar	45 J/15	149
Dadia, mica	45 J/15	372
Govindsagar, chrysoberyl	——	157
Kanchria, iron	45 J/14	278
„ ilmenite	„	432
Kishangarh, ochre	45 J/14	396
Mandaoria, molybdenum	45 J/14	389
Neagaon, mica	45 N/4	372
Sagar, beryl	45 N/4	157
Sarwar, garnet	45 N/4	172
„ mica	„	372
Sillora, quartzite	45 J/14	57
Marwar (Jodhpur)—		
Degana, tungsten	45 J/5	487
Didwana, salt	45 I/11	448
Falodi, salt	45 A/7	448
Haripur, manganese	45 J/4	362
Jodhpur, sandstone	45 F/3	60
Kapuri, fullers' earth	——	152
Kurlo, gypsum	40 O	230
Madpura, gypsum	40 O	230

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	Sheet.	Page.
RAJPUTANA—*contd.*		
Marwar (Jodhpur)—*contd.*		
Makrana, marble	45 I/12	59
Nagaur, gypsum	45 E/12	230
Pachpadra, salt	45 C/1	448
Sarangwa, marble	45 G/11	59
Shaokar, gypsum	40 O	230
Sojat, zinc	45 G/9	489
Mewar (Udaipur)—		
Gangar, iron	45 K/12	278
,, mineral water	,,	387
,, manganese	,,	362
Jawar, silver-lead	45 H/11	304
,, zinc	,,	489
Kankroli, marble	45 G/16	60
Mandal, copper	45 K/11	132
Mandalgarh, marble	45 O/4	60
Rewara, copper	45 K/8	133
Shahpura, garnet	45 K/14	173
Sirohi—		
Rohira, copper	45 D/14	133
,, gold	,,	217
,, mica	,,	372
Tonk—		
Agra, bauxite	55 E/5	22
Chattarbhaj hills, mica	45 N/16	372
Isarwas, bauxite	54 H/8	22
Kotra, bauxite	55 E/5	22

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SIKKIM, zinc	..	490
Bam, copper	78 A/8	133
Barmiak, copper	78 A/8	133
Beopertam, mineral water	78 A/6	387
Bhotang, copper	78 A/12	133
Chumbong, copper	78 A/4	133
Dajong, copper	78 A/7	134
Dentam, copper	78 A/3	134
Dikchu (Lindok), copper	78 A/11	134
Great Rangit R., coal	78 A/8	112
Jugdum, copper	78 A/4	134
Lingui, copper	78 A/12	134
Mik, copper	78 A/8	134
Momai, mineral water	78 A/9	387
Mongbru, copper	78 A/7	134
Pachikhani, copper	78 A/12	134
Pakyong, copper	78 A/12	134
Phug Sachu, mineral water	78 A/12	387
Puklaz Sachu, mineral water	—	387
Ranglichu, copper	78 A/12	134
Rathokhani, copper	78 A/4	135
Rinchimpong, copper	78 A/8	135
Sirbong, copper	78 A/8	135
Temi, copper	78 A/8	135
Tsuntang (Cheungtong), graphite	78 A/10	224
Tukkani, copper	78 A/8	135
Yeumtong, mineral water	78 A/9	387

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TIBET, jadeite	..	283
Batang, mercury	91 N/8	364
Bongwa Tal, borax	——	25
Chak Chaka lakes, borax	61 H/14	25
Chaksam, gold	77 K/11	218
,, monazite	,,	390
Daba, gold	53 M/16	217
Kampa Dzong, mineral water	77 D/11	387
Khangma, mineral water	77 H/10	387
Manasarowar lake, gold	62 F/6	217
Pallo Letok, gold	61 J/7	218
Roksum, borax	52 O/16	25
Thok Daurakpa, gold	70 H/4	218
Thok Jalung, gold	61 H/11	218
Tirtapani, mineral water	62 A/16	387
Yoja, mineral water	78 A/13	387
TURKESTAN—		
Shahidula, jade	51 H/15	283
UNITED PROVINCES, saltpetre	..	451
Agra—		
Fatehpur Sikri, sandstone	54 E/12	60
Aligarh, borax	54 I/1	26
Allahabad, soda	..	456
Partabpur, sandstone	63 G/11	60
Seorajpur, sandstone	63 G/12	61
Almora—		
Almora, quartzite	53 O/10	61

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UNITED PROVINCES—*contd.*		
Almora—*contd.*		
Bagesar, steatite	53 O/13	465
Baidli Baghir, lead	—	305
Bainskal, lead	62 C/1	305
Banini Devi, graphite	53 O/10	224
Chiteli, slate	53 O/5	61
Dharma pass, arsenic	62 B/11	15
Dol, graphite	53 O/15	224
Dwara Hath, iron	53 O/5	280
Gangoli, copper	62 C/2	135
Gargoli, graphite	53 O/10	224
Girthi R., lead	62 B/2	305
Gumti (Gomati) R., gold	53 O/9	218
Gun, lithographic stone	62 C/2	312
Kalimati, graphite	53 O/10	224
Kosila R., alum	53 O/10	8
Ladhar R., graphite	53 O/13	225
Lohughat, slate	62 C/3	61
Mansiari, arsenic	62 B/8	15
„ sulphur	„	476
Panar (Ponaar) R., gold	53 O/15	218
„ „ „ iron	„	280
Pithagora (Pithoragarh), asbestos	62 C/2	18
Pulsimi, graphite	53 O/10	224
Rai, copper	62 C/2	136, 137
„ lead	„	305
Ralam, lead	62 B/7	305

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UNITED PROVINCES—*contd.*		
Almora—*contd.*		
Ranikhet, gneiss	53 O/6	61
Shankalpa glacier, arsenic	62 B/7	15
Simalkhet, iron	53 O/5	280
Sira, copper	62 C/1	135, 136
Sual R., graphite	53 O/10	224
Thakil hill, steatite	62 C/2	465
Tuchida, lead	——	305
Banda—		
Banda, mineral water	63 C/7	388
Benares, soda	..	456
Benares, mineral water	63 O/3	388
Dehra Dun—		
Jeripani, gypsum	53 J/3	231
Kalawala pass, lignite	53 F/15	309
Kalsi, copper	53 F/14	137
Landour, mineral water	53 J/3	388
Mussoorie, phosphate of lime	53 J/3	426
Rajpur, lignite	53 J/3	310
Sahasradhara, gypsum	53 J/3	231
,, mineral water	,,	388
Salkot, gypsum	53 J/3	231
Timli pass, lignite	53 F/11	309
(**Jaunsar**), slate	..	61
,, zinc	..	490
Buraila, lead	53 F/14	305
Kharsi, lead	53 F/13	306

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	Sheet.	Page
UNITED PROVINCES—*contd.*		
Dehra Dun—*contd.*		
(Jaunsar)—*contd.*		
Konain, lead	53 F/13	306
Kuma, lead	53 J/2	306
Maiyur (Maiwar), lead	53 F/9	305
„ „ sulphur	„	475
Mudhaul, lead	53 F/13	306
Farrukhabad—		
Fatehgarh, pottery clay	54 M/11	290
Garhwal, potstone	..	465
Al Agar, copper	53 N/8	136
Alaknanda R., copper	53 N/3	136
„ gold	„	218
Badhangarh, asbestos	53 N/12	17
Chitawa Pipal, gold	53 N/3	218
Dasoli, sulphur	53 N/7	476
Dhanpur, copper	53 N/4	135, 136
„ lead	„	305
Ganges R., gold	53 J/8	218
Gargia R., sulphate of iron	——	467
„ sulphur	——	476
Gaurikhund, mineral water	53 N/2	388
Gwaldrum, gold	53 N/12	218
Jhak, silver-lead	53 N/8	305
Joshinath, asbestos	53 N/10	18
Koh R., gold	53 K/10	219
Kotdwara, lignite	53 K/10	310
Lachman Jhula, gold	53 J/8	218

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—	Sheet.	Page.
UNITED PROVINCES—*contd.*		
Garhwal—*contd.*		
Marbugetti, copper	—	136
Nagpur, copper	53 N/3	135
„ iron	„	280
„ sulphur	„	476
Nandpryag, sulphur	53 N/7	476
Niti (Juwar) pass, arsenic	53 N/13	15
„ „ „ sulphur	„	476
Patal, lead	—	305
Pindar R., gold	53 N/8	219
Pipuli, copper	—	136
Pokri, copper	53 N/3	136
Pringlapani, copper	—	136
Ramganga R., gold	53 K/14	219
„ „ sulphate of iron	„	467
„ „ sulphur	„	476
Sona R., gold	53 K/10	219
Tapoban, mineral water	53 N/11	388
Ukhimath, asbestos	53 N/2	18
Ghazipur, salt	..	448
Hamirpur, steatite	..	465
Puraini, gypsum	54 O/13	231
Jalaun—		
Karim Khan, kankar	54 N/7	61
Marhapur, salt	54 N/7	449
Jhansi, steatite	..	465
Gokhal, gypsum	54 O/5	231

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	Sheet.	Page.
UNITED PROVINCES—*contd.*		
Jhansi—*contd.*		
Gonti, gypsum	54 O/1	231
Saurai, copper	54 L/15	137
Mirzapur, ilmenite	..	432
„ manganese	..	362
„ soda	..	456
Bichi R., marble	63 L/16	62
Chunar, sandstone	63 K/16	62
Korchi, iron	63 P/8	281
Mirzapur, sandstone	63 K/12	62
Umlah Ghat, sulphate of iron	63 P/6	467
Naini Tal—		
Balia R., lignite	53 O/11	309
Bijapur, iron	53 O/12	280
Dechauri, iron	53 O/7	280
Dhaniakot, iron	53 O/7	280
Dhapila, gypsum	53 O/7	231
Dhela R., lignite	53 O/3	309
Jakh, alum	53 O/7	8
Jham, iron	53 O/12	280
Khurpa Tal, iron	53 O/7	281
Loha Bhabar, iron	53 O/3	280
Nihal R., gypsum	53 O/7	231
Ramgarh, iron	53 O/11	280
Partabgarh, soda	..	456
Kindauli, peat	63 G/9	397

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—	Sheet.	Page.
UNITED PROVINCES—*concld.*		
Tehri Garhwal—		
Aglar R., slate	53 J/3	62
Jamnotri, mineral water	53 I/8	388
Palia (Wazirgarh), mineral water	53 J/5	388

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